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Metals and Alloys

THE ENGINEERING MAGAZINE OF THE METAL INDUSTRIES

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NOVEMBER 1942

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Metals and Alloys

THE ENGINEERING MAGAZINE OF THE METAL INDUSTRIES

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VOLUME 16 • NUMBER 5 • NOVEMBER, 1942

This Month

Desulphurizing of Cast Iron 876
GEORGE S. EVANS

Alloy Steels for High Temperature Service—II 881
R. F. MILLER, G. V. SMITH AND P. A. JENNINGS

Fluorescent Magnetic Inspection 886
W. E. THOMAS

The Properties of Pure Nickel—II 891
E. M. WISE AND R. H. SCHAEFER

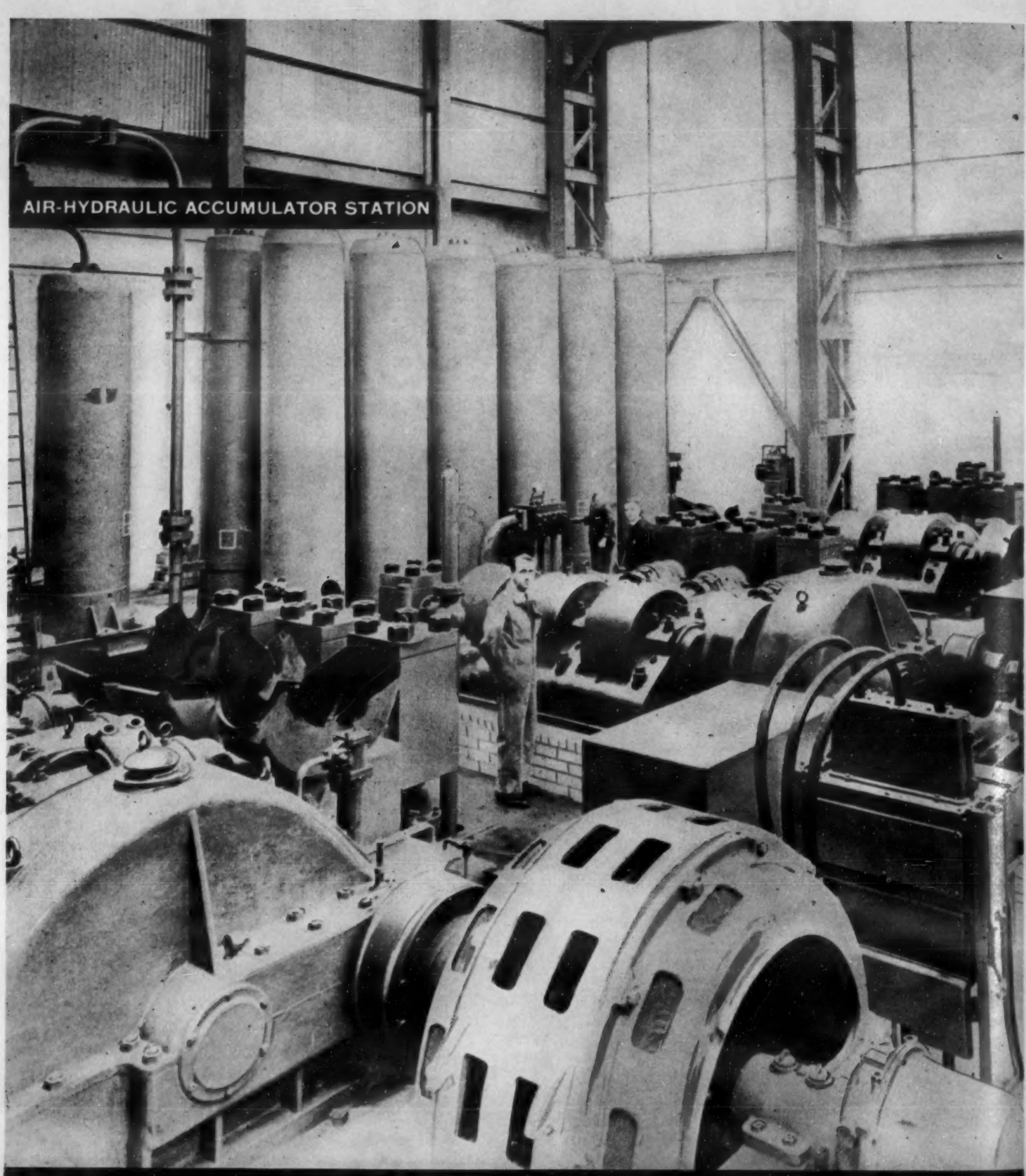
Repeated Stress Relieving Treatments on Steel Plate . 894
F. EBERLE AND T. BRICK

Every Month

The Production Front 845
Highlights 871
Editorial 873
Metallurgical Engineering Shop Notes 905
Books for Metallurgical Engineers 984
Manufacturers' Literature 986
Metallurgical Engineering News 995
Advertisers and Their Agencies 1024
Trends 1026

Metallurgical Engineering Digest

Production 912
Processing and Fabrication 930
Design and Application 954
Testing and Control 972



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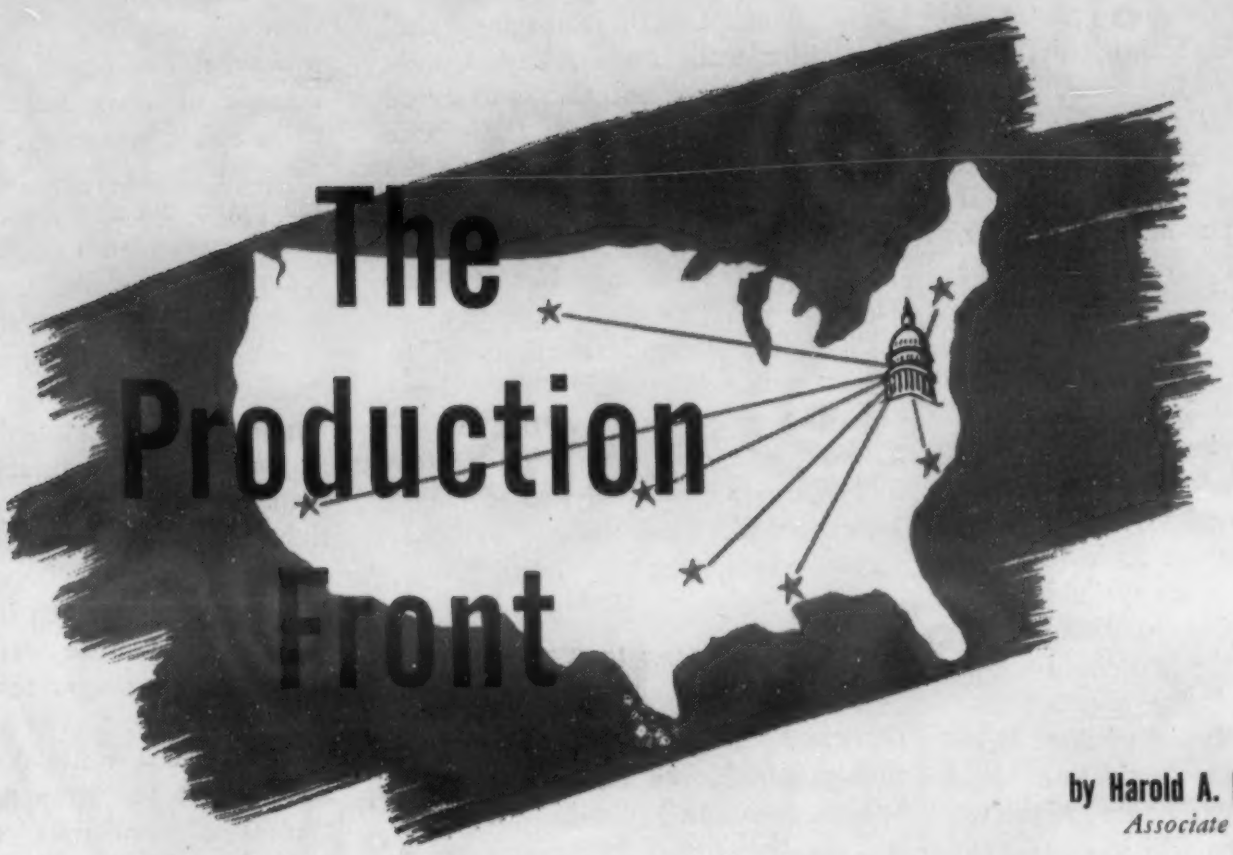


by Harold A. Knight
Associate Editor

Donald M. Nelson calls scrap drive "amazing". . . . Steel output over par first time since 1929. . . . Public becomes metal-conscious. . . . Tin improves steel. . . . Lighter scrap causes redesign of furnaces. . . . Dormant scrap spotters have outsider's viewpoints. . . . September war production 7 per cent higher. . . . Five principal alloying metals from outside U. S. . . . "Alternate" superior to "substitute". . . . Bouquets thrown sparsely at Washington. . . . Enter, "cold-treating". . . . Quality tops quantity. . . . Less glamour but more cold facts at National Metal Congress.

Army Ordnance saves critical materials drastically. . . . Four procurement heads are better than one. . . . Deliver first and red tape afterwards. . . . Army Ordnance does good organizing. . . . Speedier ships snake away from submarines.

Strategy and Tactics

"Turning point in World War II came in late 1942 when 130,000,000 American people united in mass action as never before to collect metal scrap. Up to then it seemed that the steel furnaces in the 'arsenal of democracy' would go hungry and the production effort lag. The mountains of scrap collected in cities, villages and farms from Maine to California allowed steel production for the week of October 19th to reach 101 per cent of capacity, the first time par was passed since May, 1929, when the average for the month was 101.68 per cent. WPB Chairman Donald M. Nelson stated: 'The scrap drive has achieved amazing results!' This period of delicate balance between success and failure is comparable to the first World War, when the Paris taxi army saved France."

So perhaps will the historian of 2042 describe us when writing on "The Past Hundred Years." We quote further: "No one action ever united the American people so closely as scrap collection. Up to then they had talked patriotism, but deeds are infinitely more powerful than words.

"Of course, at that time the Americans were not imbued with the fierce patriotism of the Russians whose soil was invaded and civilian men, women and children brutally murdered. Yet this was the real beginning of cooperative effort in deed, as distinct from mere lip service. The puny Boy Scout, bringing in a metal bed, felt as important a steel maker as Eugene G. Grace."

Public Became Metal Conscious

"The public then became extremely metal conscious. Womens' clubs talked of the relative merits of cast iron, carbon steel and alloy steel. Manufacturers of metal products thereafter concentrated on metallurgical quality to the same extent as eye appeal. Just as the first World War put the chemical industry on its feet, so did the second War usher in a new era of metals.

"Today one cannot imagine the ignorance as to the finer points of metals that existed a hundred years ago. Seldom could the average man distinguish tin, silver, nickel and other white metals from one another."

But we will leave the reading of the rest of that history to our great grandchildren and tell things in our own words hereafter.

Our own first thoughts were that the steel makers can never make a good product from all the "cats, dogs and porcupines" we have seen on civic scrap piles. We recall when a large steel maker a few years ago would reject 15 carloads of delivered scrap at a time because of some small inferiority or deviation from specifications (though we often suspected the market had gone against them between purchase and delivery).

Tin from Cans Improve Steel

But today, "beggars can't be choosers." Emergencies must be met by unorthodox procedures. Today steel metallurgists can use scrap of impossible quality a few years back. Even tin cans that get to the open-

hearths instead of detinning plants can be used. Earle C. Smith, chief metallurgist of Republic Steel, stated at the recent Metal Congress: "Contrary to the long-held opinion that scrap tin cans may cause trouble if used in the open-hearth furnace, small amounts of tin actually make the steel stronger."

We have been told by foundry metallurgists that loose borings and turnings can now be used in the cupola without flying out the chimney. A maker of electric steel furnaces has redesigned them, allowing 25 per cent more space to handle the plethora of lighter scrap available during the scarcity of heavy melting steel.

About the time the household scrap has been exhausted, the dormant industrial scrap will begin to flow. We asked Walter Doxsey, president of the American Steel Warehouse Association, whose salesmen will scour plants for dormant scrap, whether they will be successful—they being salesmen and not operating or salvage experts. "They will have outsiders' viewpoints and will see potential scrap where the plant owner does not—cases where plant operators 'can't see the woods because of the trees.' "

Where Do We Get Scrap in Late '43?

What happens when the industrial dormant scrap is exhausted? We ask and answer in the same breath. There will still be the general manufacturers' scrap and mill scrap in a constant flow (though, of course, we have that now). There will still be idle buildings, scantily-used bridges and equipment of mines of doubtful paying quality.

Moreover, the government will commandeer my piano, which is 30 years old. It will take out the plumbing and sanitary ware from an empty house my neighbor bought unwisely for speculation. All automobiles made prior to 1937, say, will be scrapped. Again, theoretically, by then we will have built a large part of our tanks, guns and ammunition. We will be concentrated on using them. Then the "Production Front" will be minor.

Just now we are in the "Salvage Era." One speaks of "salvaging light" (painting walls and ceiling a light color). Salvage cocktails are served at bars, with fruits, etc. (We hope they weren't salvaged from what the last customer left). And — Heaven help us — hat designers are about to bring out a "Salvage Hat" for milady.

We may have learned never to waste profligately again. We have seen put to practical use the law of Chemistry and Physics that matter and energy are never destroyed. The junk man has been elevated to "conservation engineer."

September War Output Up 7 Per Cent

Overall war production in September was 7 per cent higher than the preceding month, but lagged somewhat behind forecasts. Production today is more than three and a half times as large as in the pre-Pearl Harbor months. Our total output of munitions this year will at least equal that of German-dominated Europe.

With estimated requirements for alloy steels during 1942 over double 1940 consumption, WPB has a broad program for augmenting supplies of alloying elements. Next year U. S. chromium production will be nearly 250 times as large as 1940 output. In 1941 our supply of nickel was 11 per cent less than this year. Last year we had 27 per cent less molybdenum than in 1942.

Of the six alloying metals — nickel, chromium, manganese, tungsten, vanadium and molybdenum — all but one come principally from outside the United States. In peace time the first three were almost wholly imported.

By now seventeen steel producers have been given permission to ship experimental amounts of the emergency (N.E.) steel to laboratories and manufacturers during fourth quarter.

Alternates Superior to Substitutes

Every era brings new terms and phraseologies. A fine distinction begins to appear between "alternates" and "substitutes." An "alternate" material is one that may prove better than the original. "Substitute" is a somewhat discredited word (possibly because of drug store experiences), and implies inferiority. The alternate material might have been discovered years ago but for inertia.

Pet names and slogans for metals spring up occasionally. Thus, copper is the "everlasting metal"; zinc is the "Cinderella metal"; molybdenum is "moly" for practical reasons. We ran across a poetic description of magnesium: "The miracle metal that's both fire for incendiary bombs and lightness and strength for the bombers that drop them."

A word for the men in Washington who administer the war metals: We all know tall stories to illustrate the alleged dumbness. For instance, about the bolt- and nut-maker furnishing his product for army tanks. "Rush 50,000 bolts and nuts" read the telegram from Washington to Cleveland. "Held up — redesigning threads" from Cleveland to Washington. From Washington: "Send bolts now, and threads later."

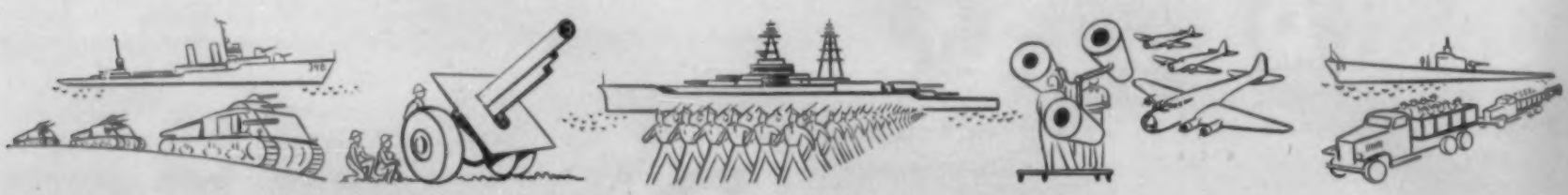
Bouquets to Washington Branches

Pertaining to some departments at Washington we have heard persistent reports of excellent jobs performed. One by the Tin-Lead Branch, WPB, especially pleases us since the head, Erwin Vogelsang, is an old friend of ours in the downtown New York metal dealer fraternity. Another is the Pig Iron Branch, WPB, which has conducted affairs as veteran business men would.

Army Ordnance has also generated sound waves that have struck our ears pleasantly. Duncan W. Fraser, president of the American Locomotive Co., stated recently: "The army men whom we have contacted know their business from 'A to Z.' They are quick, hard-driving and efficient. Our men up and down the line respect them. They help us to get things done."

"Cold" Augments "Heat"-Treating

The present metallurgical era has also developed what might be called "cold-treating" in contrast to heat treating. An aluminum rivet is kept



at 20 deg. below F., thus contracting it so that it fits well in a close-tolerance hole. A sub-zero cabinet has been devised whereby turning a dial, as on a safe, will deliver a box of rivets of desired size.

Refrigeration keeps aluminum sheets from age hardening. Bearings are fitted on shafts through contrasts of temperature. Welding electrodes are refrigerated to make more uniform beads. Cutting oils are being cooled by refrigeration.

A huge cold storage plant in Chicago, four city blocks, is serving as a laboratory for airplane engines. It maintains temperatures of 16 deg. below and 18 and 35 deg. above zero.

Impressions of the Metal Show

Here is a thumb-nail sketch of our impressions of the National Metal Congress at Cleveland in mid-October, though we are not centipede, telescope, X-ray, or sound detector, hence, we can't contact everything. Attendance at the exposition for the week was 46,538, official figures, largest in history. Total registration for the four participating societies was a new high of 25,285. As many as 1800 attended a single session.

Absent were the booths of the large steel companies, the glamour boys of other years. Newcomers who are now in the money partly made up the deficit. There were fewer booths with machines that run, gas that roars and hammers that pound.

Interest in technical sessions was particularly keen because of rapid metallurgical progress in a year. Sessions on N.E. steels were particularly standing-room-only and, for its limited scope, powder metallurgy had 'em standing in the aisles. Salvage, the topic of the day, was, strangely enough, attended lukewarmly.

Outside the convention halls war conditions were evident on every side. One waited in line for hotel meals. Getting a night reservation home took chicanery. One of us got a berth with a doctor's prescription; another, a part time WPB man, showed his government badge, by heck!

War Quality Versus Quantity

A new era in our war production effort was ushered in by President Roosevelt's announcement that our original production goal of armament would be curtailed in favor of quality rather than quantity.

The Battle of Britain "when never before were so many dependent on so few" — when fewer, but superior, British fighting craft staved off the mass production German planes first demonstrated that quality is tops over quantity.

Again our formidable flying fortresses have brought home the same lesson. War quality today means concentrated fire power and ability to "take it."

We wonder, now, if the next application is to be on fighting manpower. Will the original idea of 10,000,000 armed men be shrunk as to numbers, but expanded as to calibre of man? Is the drafting of teen-age boys and tendency to put the older men in munitions plants another application of quality?

After all, mere thousands of Germans succeeded in defeating millions of French in the spring of 1940.

On the way home (all by daylight) we saw hundreds of tank cars bringing oil to a shivering East. New York Central rails were badly worn, and in the diner we spilt half our Manhattan through slopping.

Ordnance Achieves Huge Materials Economies

The Army Ordnance Department by 1943 will be saving huge quantities of critical materials. The 1943 savings of aluminum alone, according to unofficial estimates, will reach 500,000,000 lbs., or nearly the total of the metal used in the United States during 1939.

Detailed estimates: From aluminum to pressed steel bomb fins, rack clips and other bomb equipment, more than 50,000,000 lbs. of the light metal already saved this year, and more than 150,000,000 lbs. will be saved during 1943. From aluminum to plastic shell fuses, more than 7,000,000 lbs. already saved this year, and something like 35,000,000 lbs. to be saved in 1943.

Substitutions of other metals and materials for aluminum in 93 major ordnance items, involving redesign and respecification of 416 parts, have saved an estimated 50,000,000 lbs. in 1943. Other items, now under test, will bring the 1943 total saving near the one-half-billion-pound mark.

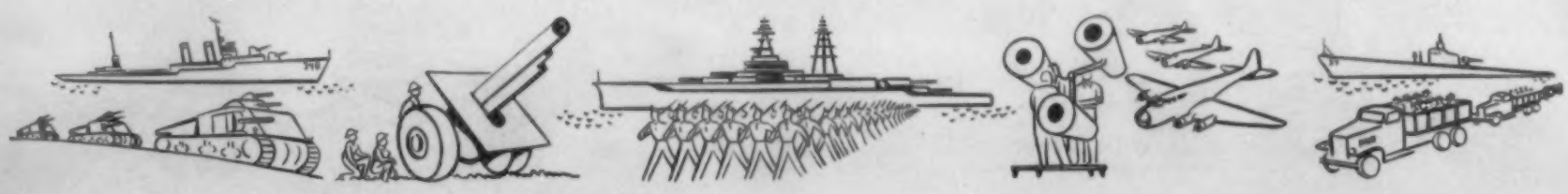
Substitution of pressed steel for brass cartridge cases, an epic achievement, will save upwards of 50,000 tons of copper and 18,000 tons of zinc this year, and an estimated 300,000 tons of copper and 115,000 tons of zinc in 1943. This 1943 saving represents nearly one-half of the total use of copper in the United States in 1939.

"Four Horsemen" of Procurement

To achieve its objective, the new "high command" of the War Production Board must undo much that has been done by WPB and its predecessors to date. Under the chairmanship of Charles E. Wilson, president of General Electric Co., four top procurement officials will meet twice a week. Mr. Wilson "will be top production authority in the war program, and will have the responsibility of seeing to it that programs and schedules for all phases of our war effort are met."

Lack of production engineering in high places has resulted in plethora of student orders about minutiae, and trifles have been magnified into mountains of paper work. Here is the down-to-earth quartet:

Lt.-Gen. Brehon B. Somervell, commanding general, Service of Supply, and boss of the Ordnance Department, Quartermaster Corps., Corps of Engineers, and Signal Corps — the Army's most important procurement



offices;

Maj.-Gen. Oliver P. Echols, commanding general, Materiél Command, Army Air Forces, the largest procurement office in the Army;

Vice-Admiral Samuel M. Robinson, director, of materiél and procurement, U. S. Navy, who heads up all Navy procurement; and

Rear-Admiral Howard L. Vickery, vice-chairman, U. S. Maritime Commission.

Controlling the war production program is essentially a production job, and no one without a background of production engineering can be expected to solve the ramified problems. This the Army and Navy know, as evidenced by the shift of many experienced production engineers from WPB, where they had little or no authority, to Army Ordnance, the Naval Bureau of Aeronautics, and other Army and Navy departments.

The log jams of paper work and countermanded rulings, the priorities and allocations systems, and confusion built up by WPB and its predecessor organizations must be torn down before the way can be cleared for mass production armament.

Red Tape and White Paper

Controversy surrounding the proposed Steel Budget Plan to succeed Production Requirements Plan hinges around whether the paper work shall be done before or after the materials are shipped to the factory. Bernard M. Baruch, production boss of World War I, is said to favor making out all the blanks and forms prior to shipment.

However, many an automotive and other mass-production executive, fed up with red tape and white paper, want materials for guns, tanks and ammunitions shipped as soon as possible after the contract is signed, doing the paper work simultaneously with the shipments, or even after.

Formula-hunters are busy seeking to "align, justify, or correlate" these two points of view, a WPB spokesman told METALS AND ALLOYS. "WPB can't let itself be licked on this point, because it would prove to critics that our program won't work," another WPB official, who must remain anonymous, said.

What a number of top WPB men overlook is that the whole disagreement results in widespread dissatisfaction in the way WPB has handled its materials program.

Ordnance Organization Is "Smart"

We have been taken behind the scenes of the Army Ordnance Department to see what makes production tick. Major-General Levin H. Campbell, Jr., chief, devised what is described as "one of the smartest and most revolutionary plans ever attempted."

Industry has been segregated according to the ordnance items being made. Administrators are called the "Industry Integration Committees," with a committee for each ordnance item. Each manufacturer of an item has a representative on the committee.

Integration and co-ordination are accomplished by collecting, correlating and analyzing information of two classes: First, technical information vital to efficiency in manufacturing methods; second, production statistics, necessary for high production and materials economy.

Information includes itemization of production facilities, actual and projected rates of output and inventories of finished parts, material in stock and material on order, and schedules of delivery dates of each contractor. Hence, many plants can function as one company. Smaller firms and late comers are supplied with latest technical and engineering data.

The Ordnance Department obtains an over-all perspective as to production capacity of the plants as a whole. Thus, materials and production can be juggled around among members with minimum of lost motion, with the future planned intelligently.

There is widespread interchange of material parts, tools, machines and technical knowledge among the member companies. Interchange of property is by sale or barter.

Mechanical time fuzes were the first to be integrated under this plan. Maximum production was attained a year ahead of schedule and without building two additional factories, originally planned.

The whole system works out like a well-organized large family—the older children help take care of the youngsters, relieving the parents (here, the Ordnance Department).

Greater Ship Speed Plus Tonnage

Rear-Admiral Howard L. Vickery, vice chairman U. S. Maritime Commission, spark plug of our shipbuilding program, recently addressed the University Club in our home town. The admiral is a solid chunk of a man, with lots of hair on his wrists. He impressed us as somewhat slow but sure — yet not so slow in getting around — he hops from shipyard to shipyard in his own airplane.

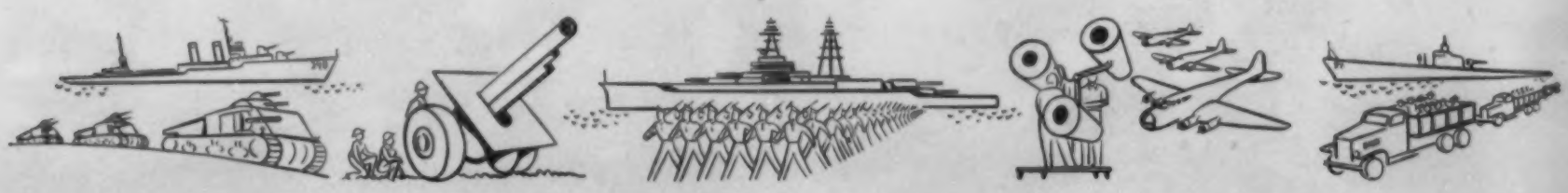
He seemed well satisfied with our shipbuilding program. Gave us a new idea — not only are we building phenomenal tonnages but the Liberty boats are much faster — 16 knots rated, we recall — which means they can outmaneuver the 9-knot boats and make it all the harder for submarines. So it is speed, plus tonnage, that will win.

Controlled Materials Plan

The new Controlled Materials Plan will supplant Production Requirements Plan on July 1st, but will start working alongside PRP in second quarter. It is expected to correct those faults of PRP and other plans whereby many plants got into production too early and produced too much, thus holding in state of suppression critical materials in form of parts, waiting months for final assembly.

Under CMP all war contracts will be negotiated as to quantity and dates of delivery with respect to raw materials available. Previously such contracts were negotiated without regard to availability of raw materials.

Hereafter, the garment will be cut to fit the cloth. Previously, it was vice versa.



The Unfinished Symphony

In Volume II of "The Alloys of Iron and Chromium," published in 1940, the list of "volumes in preparation" included Volume II of Iron-Nickel, Iron-Vanadium, and Iron-Manganese. Earlier volumes in the series also listed one on "Cast Iron" as contemplated. There was also talk of a volume to deal with phosphorus, sulphur, and the gaseous elements, a sort of catch-all volume, in which boron, tellurium, selenium, etc., would also be expected to find a place.

Although their preparation has been slowed down, it is understood that the second volume of iron-nickel, and the one on iron-vanadium are so far along that, although delayed, they will appear. That on iron-manganese appears to be in a very embryonic state, while those on "Cast Iron" and on "Miscellaneous Alloying Elements" seem to be titles only. Equally in order will ultimately be a volume on "Low Alloy and N. E. Steels."

The staff formerly engaged on the editorial work has dispersed to take up work more immediately connected with war effort in one way or another, a move with which we have no quarrel. As opportunity permits, the International Nickel Co. and the Vanadium Corp. of America, whose cooperation was enlisted for the pending Iron-Nickel II and Iron-Vanadium, will presumably carry on to the completion of those volumes whether the old Alloys of Iron Committee or a reorganized one continues to function or not.

The original hope was that the royalties on the earlier volumes would amount to a revolving fund that would serve to perpetuate the Committee organization and its editorial staff and permit revision of the volumes, one by one, as they became out-of-date, but the preparation of the books proved so expensive that this hope was not realized, so that further financing would be required. Funds that might otherwise be allocated to such a purpose are probably earmarked for taxes, and even if steel executives could find the funds, they can't find the time to consider requests for funds. So it's not very clear where the Committee goes from here, or whether it can go at all.

A compilation of all pertinent facts up to this date of publication, in which one can be reasonably sure that a competent appraisal has been exercised as to what is pertinent, is of real value. It would be nice if the date could be moved up from time to time by revision, but we may be thankful for the clearing of the ground up to some certain date.

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In 1842, men came to the little Ryerson store for iron to make horseshoes, axles and rims for wagon wheels. Today, there are ten great plants in as many key industrial centers.

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The omission, so far, of the volume on Iron-Manganese is the most serious, for manganese is our alloying mainstay. All the missing volumes should ultimately be added. In spite of our pre-occupation with problems of more immediate bearing on the war, we should not forget this job.

It ought not to be left unfinished,—H.W.G.

Comment by Frank T. Sisco

I appreciate the privilege of commenting on this issue's editorial by Dr. Gillett on Alloys of Iron Research, entitled "The Unfinished Symphony." When Alloys of Iron Research was organized in January 1930, the funds subscribed by The Engineering Foundation, Battelle Memorial Institute, the National Bureau of Standards, several technical societies, and industry were ample to review the literature, correlate the data, prepare and edit manuscripts, and publish in five years a series of some 10 to 12 monographs covering the metal iron, carbon steel, ordinary cast iron, alloy steels, alloy cast irons, and special iron alloys.

The depression, which began late in 1931, resulted in a reduction of industry contributions of about 40 per cent, making it necessary to reduce the staff and, in 1935, to refinance the project. Meanwhile the world's metallurgical literature grew by leaps and bounds increasing by 50 to 100 per cent the amount of work necessary to complete the unfinished monographs.

For example, it was estimated early in 1930 that chromium as an alloying element in steel and cast iron could be covered in a book of 450 pages; by the time the manuscript for "The Alloys of Iron and Chromium" was finished, however, enough important data had accumulated to make two volumes, totalling 1095 pages, necessary. Similar conditions prevail for the monographs on nickel, manganese, and vanadium. Slowing down the work and extending the time has, of course, had the advantage that the monographs published since 1937 are much more valuable than they would have been had they been completed in 1933 or 1934.

At the last meeting of the Iron Alloys Committee in February 1941, refinancing was brought up, and the discussion included the comments by editors and prominent metallurgists from all over the world—to the effect that Alloys of Iron Research be made a continuing project to bring published monographs up to date at 10-year intervals and to prepare monographs on alloys of iron and phosphorus, sulphur, aluminum, and other elements not included in the present series. As it was shown at that meeting that industry would not be sympathetic to continuous support, the committee voted to discontinue the work when funds on hand or pledged were exhausted.

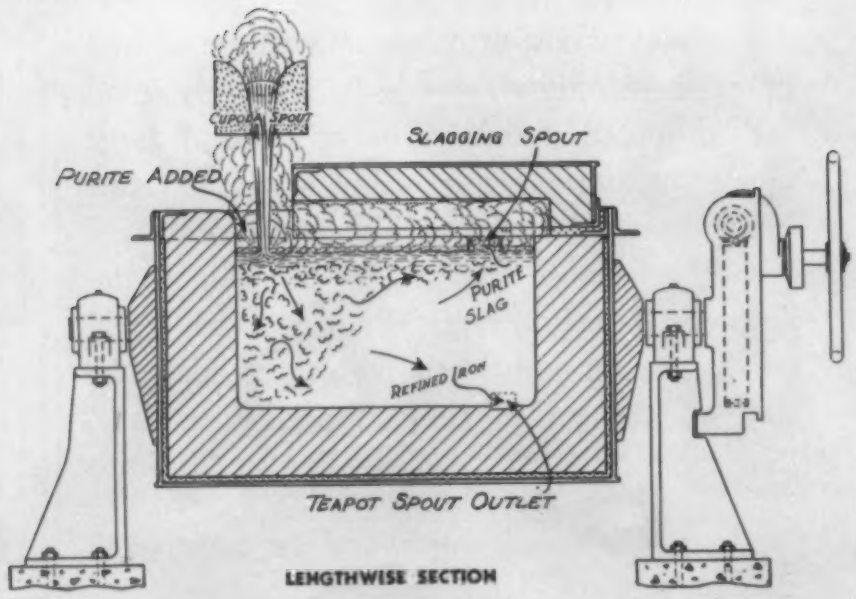
These funds, plus a subsequent small appropriation by The Engineering Foundation, are sufficient to keep Alloys of Iron Research going on a very reduced scale until late in 1943. The present program involves the publication of Vol. II of "The Alloys of Iron and Nickel—Steels and Cast Irons" (being finished by what remains of the Alloys of Iron staff) and of "The Alloys of Iron and Vanadium" (being written by The Vanadium Corp. of America). Considerable work has already been done on "The Alloys of Iron and Manganese"; the chapters on the constitution of the alloys have been written by F. M. Walters, Jr., and a large amount of data has been accumulated for the chapters on properties. A concentrated effort will be made to complete this monograph, but this may be impossible.

The annual cost of continuing Alloys of Iron Research indefinitely would be relatively small and, if spread equitably among some 50 large producers and users of alloy steels and cast irons, would be of small moment compared with the benefits and savings accruing to industry at large and especially to research workers, engineers, and others who must know the state of the art in their respective fields.

—FRANK T. SISCO

(Editorials continued on page 902)

The U-shaped teapot ladle.



LENGTHWISE SECTION

Desulphurizing of Cast Iron

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One of the reasons modern cast iron is an engineering material with properties 100 per cent better, in some cases, than those generally available in the cast iron of 10 or 15 years ago is the use of advanced refining techniques as part of a closer overall metallurgical engineering control. Refining and desulphurizing of cast iron with soda ash or caustic soda (or mixtures thereof) is being increasingly applied. In this article the practical use of these reagents as ladle or cupola additions, and some results obtained are described. —*The Editors.*

DESULPHURIZING IN IRON FOUNDRIES was started on a commercial scale shortly after the first World War. Originally desulphurizing was looked upon simply as a means of using high percentages of scrap in the cupola charge and to offset oxidation and high sulphur pick-up in the cupola coming with the use of the generally inferior foundry coke supplied to foundries following the first World War. Today, however, the refining that comes with the proper use of soda ash in foundry operations, whether in the cupola or mixer ladle, is considered of far more value than simply removal of sulphur.

This use of the alkalies for refining and desulphurizing cupola iron in foundries has developed along three separate and distinct lines, namely:

1. Desulphurizing and refining in mixer ladles as a means of improving the physical properties of the metal.
2. Refining and desulphurizing in the cupola with improvements in melting operations.
3. Desulphurizing in duplexing processing where the prime object is the removal of sulphur.

Desulphurizing and Refining in Mixer Ladles

In refining iron from the cupola for pouring castings, removal of sulphur is usually secondary to the over-all effect of the refining upon the pouring quality of the metal and physical properties of the finished casting. For best results, the treatment in mixer refining ladles is generally limited to from 2 to 15 lbs. of soda ash per ton, and the metal held in the ladle in contact with the soda slag from 3 to 20 mins., with sulphur reduction of from 10 to 50 per cent, varying with the mixture and class of casting produced.

There is always some loss of temperature with desulphurizing; however, with proper mixer ladle equipment adapted to fit in with the particular operations and when limiting sulphur reductions to some 30 per cent, the effect of the drop in temperature upon fluidity of the iron is usually more than offset by the action of the refining in increasing fluidity. With higher percentage reductions the chilling effect of the added reagent and drop in temperature due to longer holding time usually causes a net loss in fluidity.

For this reason the refining of metal for pouring light castings such as stove plate, automobile and light machinery castings is generally limited to reduction of some 20 to 30 per cent of the sulphur contents of the iron at the cupola spout. This extent of refining will generally produce the maximum fluidity in the molten iron and maximum improvements in strength and machining qualities of light machinery castings. On metal for pouring heavy castings where the iron can be poured at lower temperatures, sulphur reduction of 40 to 50 per cent or more is entirely practical.

Cupola iron is always charged with gaseous compounds and silicious or non-metallic impurities, more or less varying with the character of the charge, melting practice, and refinement of the metal in the hearth of the cupola. The alkalies are chemically more reactive with these entrained silicates than with combined sulphur in cast iron—forming liquid soda silicate slags which rise out of the iron.

Gaseous sulphur is driven off in part by the boiling action set up in the iron or is washed out along with undissolved manganese sulphide by the soda slags. This refining action, which is very rapid, may require less than 1 lb. of soda ash treatment per ton on high steel mixtures to clear the iron of these loosely held gases or suspended inclusions, and upwards of several pounds per ton on mixtures carrying high percentages of burnt cast scrap. Any free alkalies remaining after satisfying these entrained impurities react with iron sulphide (FeS) and iron-silicon reducing both sulphur and silicon. This reaction goes on at a comparatively slower rate and, when carried too far, acts to reduce fluidity of the iron; thus illustrating the necessity of adapting the treatment—both as to quantity of reagent per ton and time allowed for completion of the refining—to fit the class of castings produced.

The maximum benefit of the refining as expressed by the effect upon castability of the metal will generally coincide with the removal of occluded gases expelled by the boiling action set up by the treatment and the removal of entrained oxide silicates and other non-metallic impurities which are washed out of the iron and carried off in the soda slag. This together with the better mixture resulting with the mixer ladle and the effect of the refining in flattening out variations make for more uniform temperature and analyses—and the refining tends to break up the phosphide areas, reduce the size of graphite particles, and result in a more uniform dense structure iron. (See photomicrographs)

U-Shaped Mixer Refining Ladle

Development a few years ago of the U-shaped mixer refining ladle with cover and insulation has served to extend refining in the gray iron industry to an increasing number of foundries during recent years. This type of ladle is not adapted to maximum per cent desulphurization but is particularly efficient as a mixer refining ladle; and by providing a continuous supply of refined metal is well suited to production foundries.

These ladles require minimum cupola headroom for installation, minimum volume and depth of iron for complete refining and, by holding temperature loss in the mixer ladle to a minimum, make the refining equally practical for heavy or light castings and for foundries melting as low as two or three tons per hour.

The iron from the cupola and the refining agent enter the ladle at one end, and the refined iron is drawn off from the bottom of the ladle through a teapot spout at the far end. This restricts agitation of the bath due both to the stirring action of the stream and the violent boiling action set up by the reagent to one end of the ladle. Entrained impurities are converted into liquid soda slags which rise out of the bath as the iron travels across the ladle; thus providing a continuous supply of quiet desulphurized and refined iron at the teapot spout. (See illustration.)

Refining and Desulphurizing in the Cupola

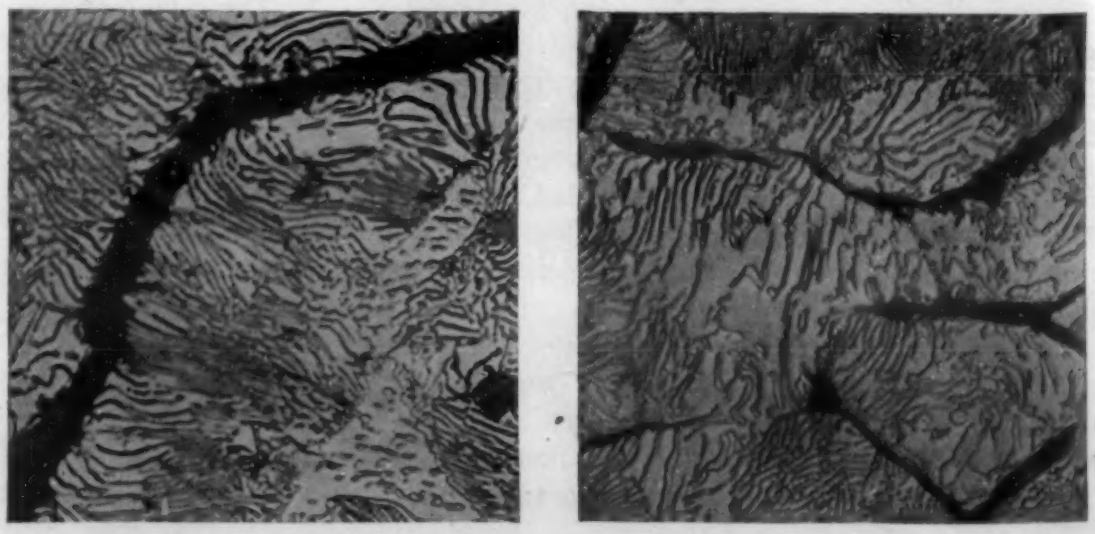
There has been a gradual increase in the use of fused soda ash in the cupola during the past few years. This use has been held back by fear of the cutting action of soda slags on the cupola lining. It has now been proven, however, that with the proper application in the cupola particularly when melting high steel mixtures which are notably hard on the lining, soda ash serves actually to save the lining as well as to save oxidation of the metal and smooth out cupola operations. Added in the cupola along with the limestone, soda ash serves the dual purpose of improving melting conditions by making a more fluid slag, by accelerating the combustion reactions, and prevents some sulphur pick-up by the iron.

In average cupola practice 4 lbs. of soda ash per ton of metal added along with the limestone charge will lower the sulphur in the iron at the spout by about 15 per cent or from 0.11 to 0.095 per cent S. With high steel mixtures which tend to pick up more sulphur during melting, the effect is normally more pronounced; while with straight cast scrap and pig iron charges, the effect upon sulphur pick-up is somewhat less. The soda ash increases the fluidity of the slag and accelerates the combustion reactions, thereby reducing oxidation of the metal charge which, as we know, is usually more pronounced with high steel mixtures.

More recently we have learned better how to use soda ash in the cupola; now the most generally adopted practice is to use double the regular amount of limestone on the bed coke, adding 1 lb. of fused soda ash with each 10 lbs of stone, both on the bed and first 2 or 3 regular coke charges. The soda ash is reduced to 1 lb. with each 20 to 40 lbs. of limestone on the following charges or as required to maintain a good fluid slag throughout the heat. This practice provides a good volume of fluid first slag for flushing off the bed coke—it prevents excessive sulphur pick-up by the first iron and makes for a good start everyday.

Desulphurizing in Duplexing Processes

With batch or individual ladle treatment in duplexing processes, such as cupola-converter or cupola-electric steel operations, where the prime object of desulphurizing is maximum sulphur reduction, and provided with good cupola melting practice, the sulphur in the iron from the cupola can be reduced by 60 to 70 per cent with soda ash, and upwards of 85 per cent with caustic soda without lowering the temperature of the iron below the blowing range.



Photomicrographs of all scrap mixture cast iron at 1,000 X; etched with 2 per cent nital, before and after refining with soda ash. Untreated, left; treated, right. These illustrate the action of the refining —in washing out manganese sulphide and complex silicate inclusions, in breaking up phosphide areas, and in reducing the size of graphite particles.

The most important factors in efficient desulphurizing, excepting temperature of the metal are: Clean metal free of cupola slag or any silicious impurities, and rapid and intimate contact between the metal and soda slag. In order to insure clean iron, use plenty of limestone, and a slag liquefier in the cupola if necessary to produce a good fluid slag which will rise out of the iron in the hearth of the cupola, and always stop off the tap before any slag shows on the stream of iron in the spout. The soda slag is neutralized by any cupola slag or silicious materials present, which both dilute the slag and dissipate its desulphurizing value. Therefore, the ladle should always be free of loose dirt or slag before adding the reagent and every precaution should be taken to prevent any cupola slag coming out with the metal.

The stream of iron flowing into the desulphurizing ladle promotes slag metal contact due both to the physical effect of the stream in stirring the metal and to its action in whipping portions of the freshly melted or undecomposed alkali down into the metal bath. This not only increases the extent of slag metal surface contact, but makes for more effective contact because of the pressure of the overlying metal. Moreover, decomposition of the reagent under the metal surface with the consequent evolution of gases, causes a violent boiling action which acts to further increase surface contact.

To insure both clean iron and maximum contact between the soda slag and metal, the cupola tap hole should be smaller than average so as to extend the tapping time over a longer period, thus prolonging the stirring action by the stream of iron; and a small head of iron should always be held back in the cupola at the end of the tap to prevent any cupola slag coming out with the last iron.

Adding the Compound

When desulphurizing in 1 to 3-ton capacity ladles with 2 cupola taps required to fill the ladle, and when using fused soda ash such as Purite in 2-lb. pigs, about two-thirds of the reagent should be added in the bottom of the ladle before the first tap and the balance just after stopping-off the cupola. The first charge gradually melts providing a good volume of a constantly active slag which is continuously whipped into the bath during the first tap. In the second addition the pigs penetrate the slag and melt in contact with the metal, gradually releasing fresh or undecomposed alkali which causes continued boiling action and makes for maximum slag metal surface contact throughout the tap. If the ladle is filled in one continuous tap add one-half of the reagent in the ladle at the start and feed in the balance during the middle third of the tap.

The time required for completion of the reaction, which is indicated in part by quieting down of the slag, will usually vary from 5 to 10 mins. after the last tap in 1 to 3-ton ladles to upwards of 15 to 20 mins. in larger capacity ladles where maximum desulphurization is required as in converter steel practice. The operation should be timed as found by experience to give the best results and the practice thus established should be followed from day to day. Although traces of slag going into the converter are not harmful to the quality of the steel, any slag attacks the lining just that much and an excess will cause a foamy blow or bad heat, besides returning some sulphur into the iron. In cupola-electric furnace duplexing any soda slag going into the furnace will cause excessive electrode consumption. This is due to the action of the sodium flame in accelerating the combustion reactions.

Typical scene in a foundry—filling a sand mold from a ladle of hot metal.

The soda slag is very fluid but can be thickened with additions of slacked lime or limestone dust or frozen by pouring water on the surface to facilitate skimming. Sand or any silicious material should never be used for thickening the slag as these cause a reversal of the reaction. A wooden hoe-like skimmer coated with mud by dipping in a bucket of grout is preferred over the usual iron skimmer.

Ladle Linings

Soda slags are particularly reactive to ordinary clays or plastic cements used in laying up ladle brick,

and tend to eat out the joints, loosening up the brick. Most of the reports on excessive ladle lining costs with desulphurizing can be traced to the use of improper brick and to laying up the ladle lining with thick mud joints. First of all it is essential to provide a double thickness lining in desulphurizing ladles of one or more tons capacity; and for best results, the brick should be dense, hard burned, true to form and of a type that expands upon being heated up by the first iron. They should be laid up with tight joints either dry or with a milk thin grout of high-grade fire clay. Such a lining by expanding on being heated up seals the joints, making an almost monolithic lining that resists the action of alkali slags most efficiently.

Desulphurizing Reagents

The alkalies available for use in commercial desulphurizing practice include, in the order of their activity:

1. Caustic soda—(NaOH)
2. Soda ash—Caustic soda mixtures
3. Soda ash (Na_2CO_3)

The active agent in each is sodium oxide (Na_2O) —of which soda ash contains 58 per cent and caustic soda 76 per cent—thus caustic soda with 76 per cent Na_2O is proportionately more active than soda ash with 58 per cent Na_2O. Under favorable conditions upwards of 85 per cent of the sulphur present in cupola iron, within the range of from 0.06 to 0.13 per cent S, can be removed with caustic soda in one treatment without external heat. The maximum reduction obtainable when treating similar irons with soda ash is about 75 per cent.

Caustic soda, which we know as common household lye, will absorb moisture from the air and must be shipped in air-tight containers. As the name implies, it is highly caustic and must be handled with gloves. Caustic soda, because of its high concentration, lower melting point and greater activity as compared to soda ash, makes for more violent boiling action or more rapid contact between the metal and slag, which together account for the higher per cent sulphur reduction obtainable with this reagent.

Boiling of caustic slags may be prolonged in some cases by additions of soda ash and other carbonates with the caustic. With fused soda ash used with caustic or alone, boiling action is prolonged by gradual melting of the 2-lb. briquets in contact with the metal which continually provides a fresh supply of free alkali that is whipped under the bath; thus affecting some increased efficiency.

Soda ash is available as (1) 58 per cent light ash, a fine precipitated product which is too dusty for use in desulphurizing; (2) 58 per cent dense ash, also too light and dusty for practical desulphurizing operations; (3) granular soda ash, carrying 10 to 30 per cent dusty grade; (4) crystalline granular ash, containing 56 per cent Na_2O, which is practically free from dustiness; (5) soda ash briquets, containing 52 per cent Na_2O and also dustless, but carrying some fines; and (6) fused soda ash, containing plus 58 per cent Na_2O with traces of caustic. (Crystalline granular ash is sold under the trade name "Granular Purite," and fused soda ash as "Purite.") Fused soda ash is available in 2-oz. tablets, ½-lb. cakes and 2-lb. pigs. It is not only dustless, but produces less fumes and is generally more efficient than other forms of soda ash.

The Desulphurizing Reaction

Causes for the erratic or unsatisfactory results with desulphurizing sometimes reported by both blast furnace and foundry operations have usually been due to their failure to take into account the chemistry of the reactions and physical phenomena involved in desulphurizing with the alkalies. For instance, at cupolas or blast furnaces variations in the quantity of slag coming out with the metal, and at blast furnaces differences in the amount of entrained silicates, and/or kish in the different casts, will among other things materially affect results. Furthermore, the alkalies instantly unite with any free slags, dirt in the ladle, or silicates in the iron in preference to reactions with sulphur. These both dilute the reagent and reduce the slag-metal surface contact; thereby retarding the desulphurizing reactions.

To repeat, the most important factors in efficient desulphurizing practice are clean metal free of cupola slag or any silicious impurities, and rapid and intimate contact between the metal and soda slag. The stream of iron flowing into the desulphurizing ladle by stirring the metal and by whipping portions of the freshly melted or undecomposed alkali down into the metal bath cause a violent stirring action which promotes contact between the slag metal surface.

For maximum desulphurization as in converter steel practice, it is desirable to allow plenty of head room under the cupola spout to provide a good fall so that the stream will churn the iron in the ladle. For refining in U-shaped ladles where the object is primarily washing the metal of entrained impurities, a soft stream or low fall will do as well and save the ladle lining.

Alloy Steels for High Temperature Service—II

—Their Properties Compared

This is the second and concluding instalment of a survey of reliable published data on the comparative high-temperature service properties of several steels most widely used at high temperatures. The first instalment appeared in our September issue.

Fig. 5 shows the thermal conductivity of the several steels at temperatures between room temperature and 1500 deg. F. The thermal conductivity of carbon steel is lessened by the presence of alloying elements. Carbon steel, with relatively high conductivity at room temperature, decreases in conductivity with increase of temperature. The alloy steels, with lower thermal conductivity at room temperature, show an increase of conductivity with increase of temperature. In all cases, with increasing temperature, the thermal conductivities tend to come closer together until at about 1500 deg. F. all values lie within a range of 174 to 232 Btu/sq. ft./in./hr./deg. F. The change in conductivity is essentially linear up to about 1500 deg. F., above which there is little significant change of conductivity with change of temperature.

Susceptibility to Oxidation in Air

Fig. 6 shows the influence of temperature on the susceptibility to oxidation (scaling) of these steels in contact with air at temperatures between 1000 and 1700 deg. F. The values plotted represent grams loss in weight per square inch of surface area due to scaling of the specimens held 168 hrs. at temperature in a current of air. The steels are grouped in order of decreasing susceptibility to oxidation. Below 1000 deg. F., the susceptibility of carbon steel to oxidation is very slight, but above this temperature it increases rapidly with increase of temperature. The addition of molybdenum does not materially affect the susceptibility to oxidation, but addition of chromium and silicon is quite effective in the ferritic steels. The austenitic steels, containing large amounts of chromium and nickel, have very low susceptibility to oxidation.

Hardness of Air-Cooled Steels

The hardness of specimens which had been air cooled from a temperature in the range 1300 to 2000 deg. F. was measured from center to edge on the cross section of the one inch round bar. The hardness reported in Fig. 7 is the average of these measurements, the maximum difference over the cross section of any one steel being seldom more than 20 points. The initial hardness of these steels, all of which contain from 0.10 to 0.20 per cent C, between 100 and 160 Brinell, was the result of annealing or of normalizing and tempering. The data for carbon and carbon-molybdenum steels are contained in the lower band, those for the chromium-molybdenum steels in the upper band. The tendency to air harden increases markedly with increasing chromium content, and is approximately in the order shown in the two lists on Fig. 7. It should be noted that addition of titanium or columbium to 5 Cr-½ per cent Mo steel does not entirely eliminate the tendency to air harden, especially when it is cooled from the higher temperatures.

The air hardening characteristics of these steels are important not only because they show the hardness which may be encountered after routine heat

by R. F. MILLER, G. V. SMITH, and P. A. JENNINGS

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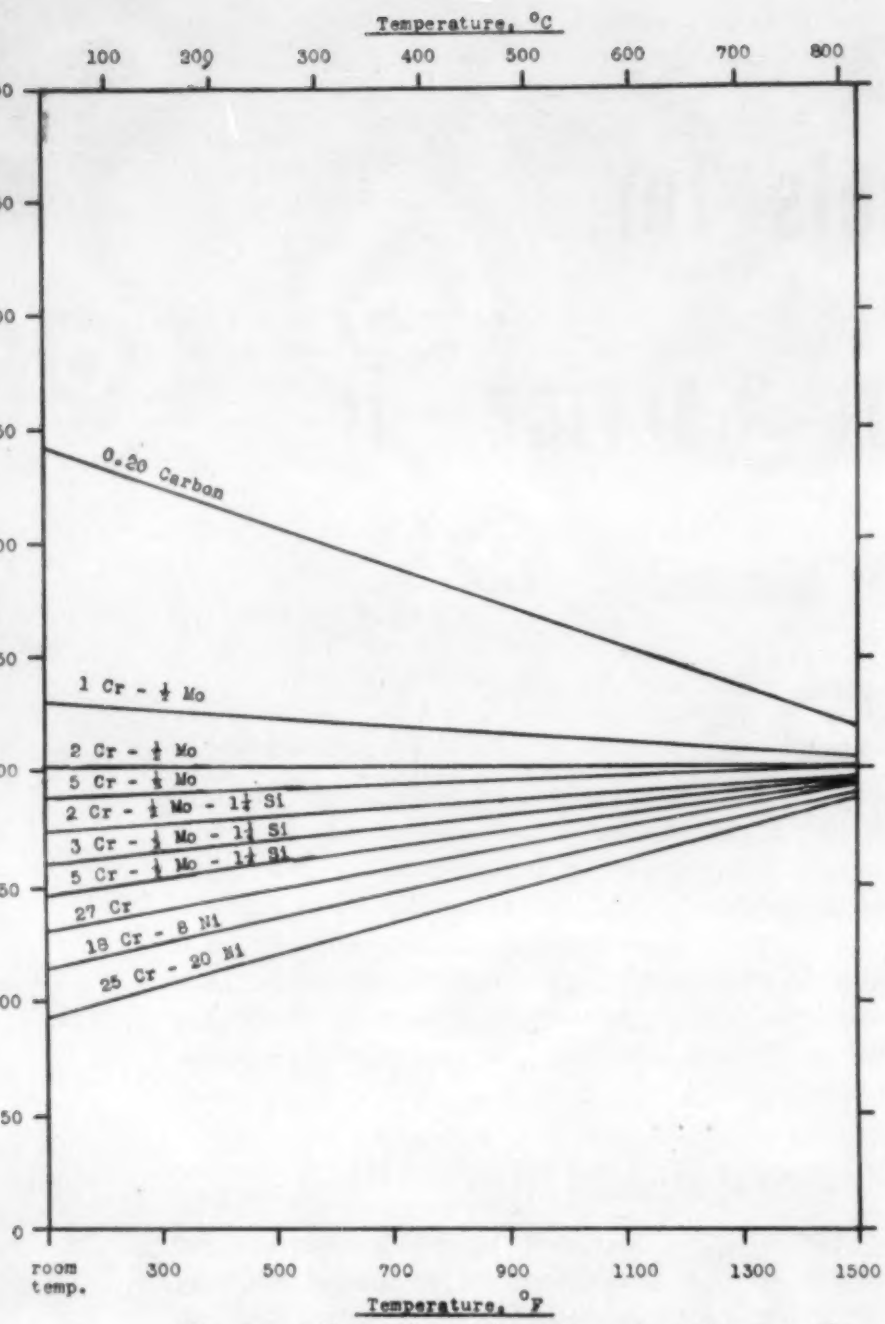

Fig. 5. Thermal conductivity of various steels at temperatures between room temperature and 1500 deg. F.

treating operations involving air cooling, but also because they indicate that hardening may occur in these steels after a welding operation unaccompanied by controlled heat treatment. It should be borne in mind that the rate of local cooling from a welding operation may exceed that of air cooling or even that of a liquid quench, and that the rapidity of cooling increases with increase of thickness of the section being welded. Obviously, if excessive hardness is to be avoided after welding any air-hardening steel, the heat-affected zone must either be slowly cooled from the welding temperature or be re-heated to soften the martensite formed by the rapid cooling.

Influence of Composition

Fig. 8 was prepared to show the influence of composition, particularly of chromium content, on four of the properties described above. In order to show these properties simultaneously on a single diagram, it was necessary to consider them at individual temperature levels. For other temperature levels, the order of the steels for the several properties would not necessarily be the same as in Fig. 8. The steels are arranged in order of increasing chromium content, except that the ferritic and austenitic steels are grouped separately. The creep and tensile strength are shown for 1000 deg. F. (The tensile strength is represented by the total length of the bar, the creep strength by the solid black portion.) Since there is negligible oxidation and no air hardening at this temperature, the effect of composition on the susceptibility to oxidation and on the tendency to air harden is shown for the level 1700 deg. F. Some of the more striking trends shown by Fig. 8 are mentioned below.

The creep strength of carbon steel at 1000 deg. F. is considerably improved by the addition of molybdenum. Moderate additions of chromium to carbon-molybdenum steels do not improve their creep strength at 1000 deg. F. The austenitic steels containing large amounts of chromium and nickel are highly creep resistant. In general, additions of molybdenum or chromium tend to affect the tensile strength in the same way as they affect the creep strength, but some exceptions are evident.

The susceptibility of carbon steel to oxidation in air at 1700 deg. F. is markedly decreased by the addition of chromium or of silicon.

In order to eliminate the error introduced by the variation in initial hardness of the steels, the *increase* in hardness after air cooling from 1700 deg. F. is shown in the last column of Fig. 8. While the increase in hardness brought about by air cooling from 1700 deg. F. is small in the case of the carbon-molybdenum steels, it is very much greater in presence of as little as 1¼ per cent Cr, and increases with increasing chromium content. This increase in hardness is offset to some extent by addition of titanium or columbium. The 17 and 27 per cent Cr ferritic steels, containing from 0.10 to 0.20 per cent C, of the type used at elevated temperature, and the austenitic steels, do not air harden.

In general, increase of content of the alloying elements commonly used in such steels is not accompanied by improvement in *all* of the properties of a steel at elevated temperature.

Some Useful Conclusions

Successful use of metals under stress at elevated temperature involves appreciation of the fact that, in many ways, their behavior is fundamentally different from that at room temperature. Some of the most important differences are as follows:

1. At elevated temperature, instead of maintaining its shape indefinitely under a working stress, metal flows continuously under even the smallest applied stress, and the rate of flow is a function of the applied stress.
2. The modulus of elasticity of all of the low alloy ferritic steels is alike, decreasing from about 30,000,000 at room temperature to about 20,000,000 lbs. per sq. in. at 1000 deg. F.; above this temperature, the modulus decreases even more rapidly. The elastic range of both the ferritic and the austenitic steels decreases with increase of temperature.
3. Metal which is cold worked (strain hardened) to increase its room temperature strength has lower creep strength than metal which is free from cold work.
4. Coarse grain material has higher creep strength than fine grain material, other things being equal.
5. Substantial increase of carbon content of the ferritic steels above 0.20 per cent tends to decrease the creep strength.
6. Loss of metal by scaling becomes important at temperatures above 1000 deg. F.
7. At elevated temperature the possibility of spheroidization or other structural change must be borne in mind.
8. At elevated temperature, the terms "ductility" and "brittleness" lose their usual connotation, for under creep conditions (very slow rate of straining) failure is normally intergranular (i.e. the grain boundaries are then weaker than the grains themselves). This intergranular type of failure does not necessarily indicate any "embrittlement" of the material nor lack of abundant plastic deformation preceding the failure. Most failures at elevated temperature are, however, not intergranular because the final strain rate is so fast that the failure is transgranular; the faster strain rate may be a consequence of overheating the metal or of increase of stress brought about by corrosion or by any other cause. Even though there may have been considerable intergranular cracking, the remaining sound metal may be no less ductile than it was originally, and may still withstand considerable bending or other rapid deformation.
9. At elevated temperature, metals have a higher damping capacity than at room temperature.
10. At elevated temperature, the fatigue strength of steel is usually greater than the creep strength.

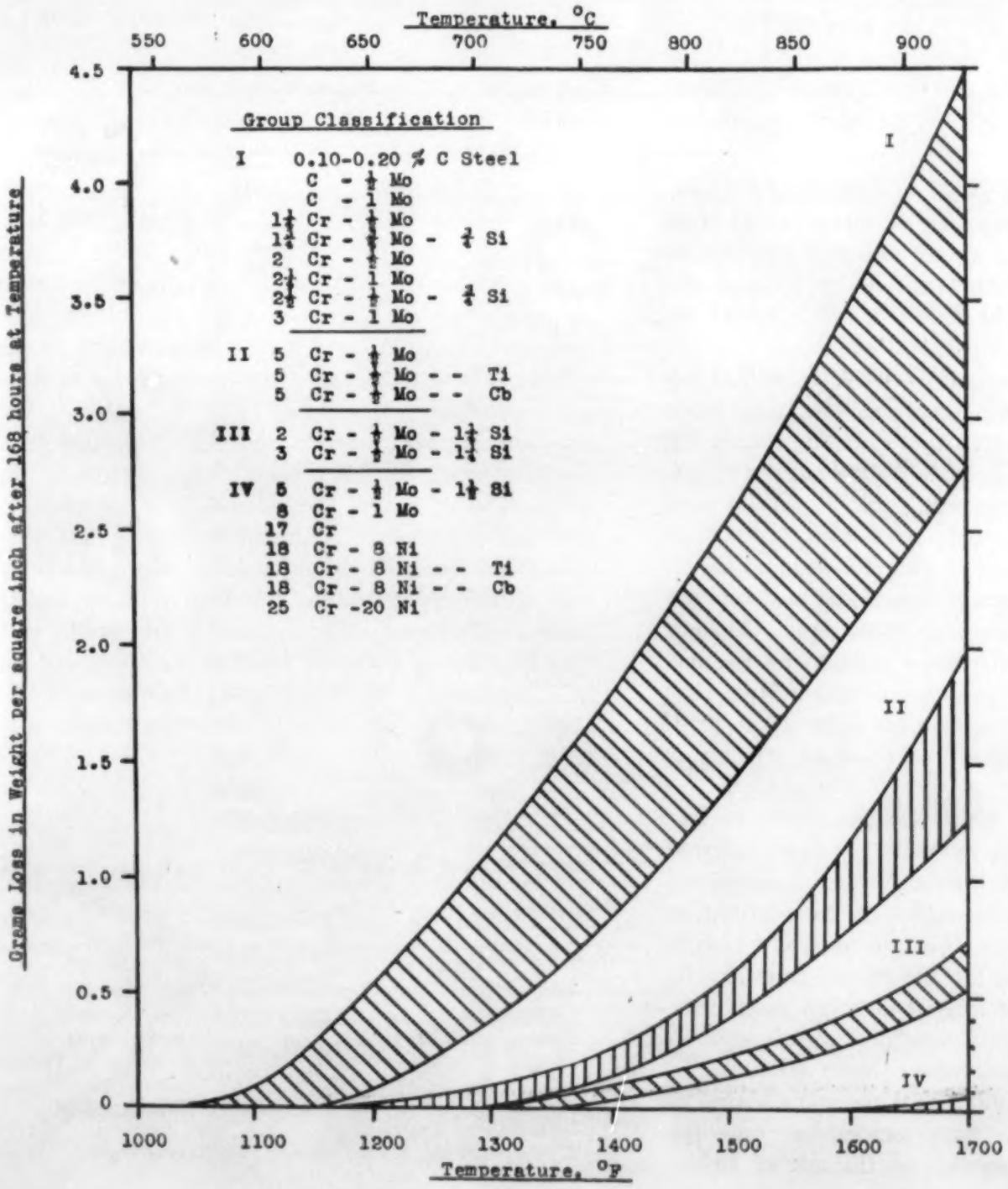

Fig. 6. Susceptibility to oxidation (scaling) of various steels in contact with air at temperatures between 1000 and 1700 deg. F.

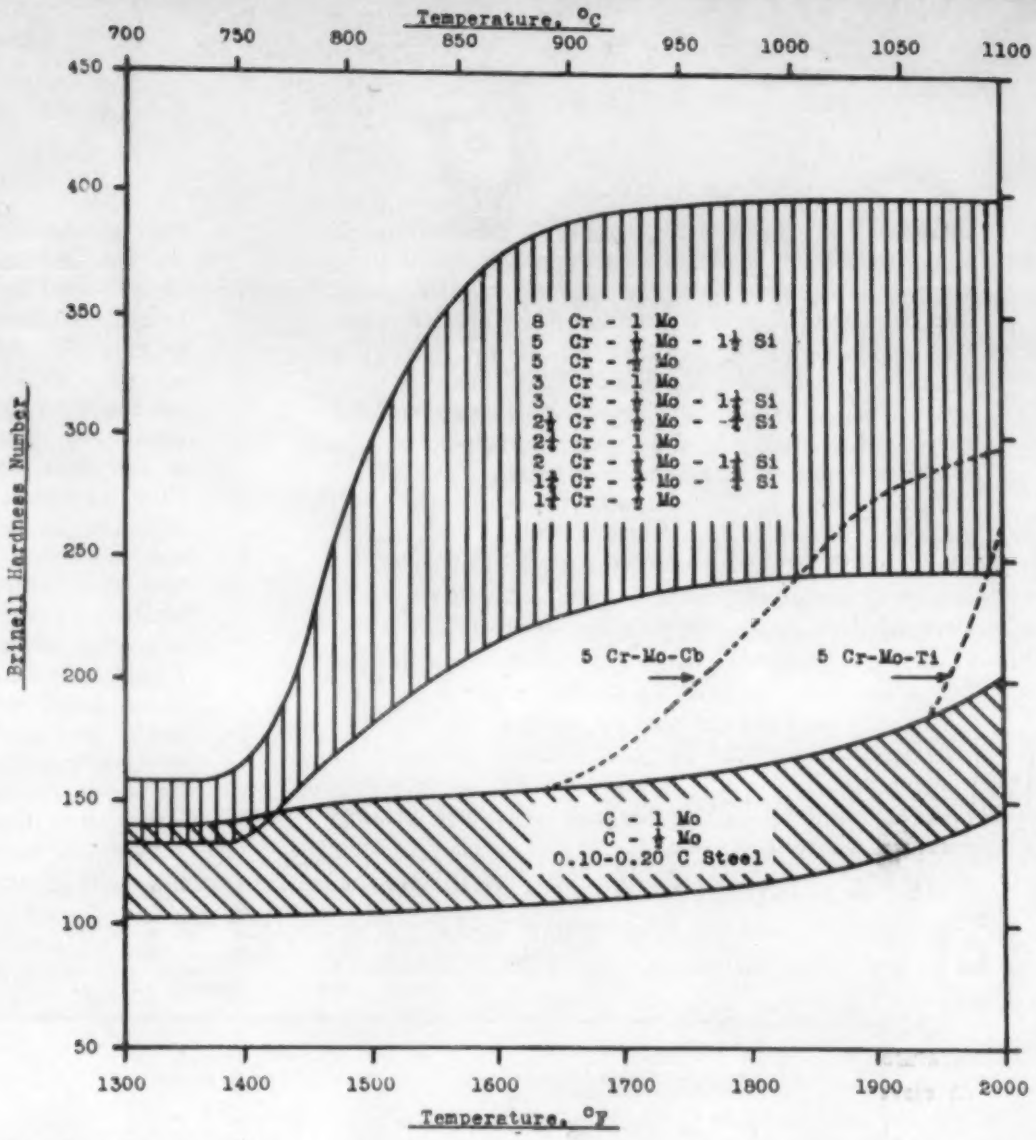

Fig. 7. Hardness of various 0.10 to 0.20 per cent C steels as measured after air cooling from temperatures between 1300 and 2000 deg. F.

It may be useful to point out briefly the reasons for the difference in behavior of metals under stress at ordinary temperature and at elevated temperature. Some of the recent publications which consider this subject more extensively than is possible within the scope of this article are listed in the Appendix.

When a metal is stressed sufficiently to produce plastic deformation, two opposing processes, strain hardening and relief of strain (softening during the time the stress is being applied) always take place. When steel is plastically deformed at ordinary temperature, softening proceeds very slowly and strain hardening predominates. As the temperature of the process is increased, strain hardening becomes less rapid and strain relief becomes more rapid. In some temperature range, which itself depends on the rate of straining, the two opposing processes balance each other; at any higher temperature, some strain hardening can still take place, but relief of strain predominates.

The temperature at which the two processes balance each other (which by some has been referred to as the "equi-cohesive" temperature) is about the same as the lowest temperature of recrystallization of cold worked material. This transition temperature range is a characteristic of the metal, and may be relatively low; *e.g.*, for lead, it is below room temperature; for the ordinary structural metals and alloys, however, it is well above room temperature. It should be borne in mind that the transition temperature is not a single fixed temperature even for a given material, but depends on the rate of straining and varies over a considerable range in a manner similar to the variation of the recrystallization temperature.

In the case of most metals under stress sufficient to produce plastic deformation, the fundamental difference in behavior at different temperatures is that at atmospheric temperature the metal begins to flow, but is gradually strengthened by strain hardening and so ceases to flow, whereas above its transition temperature range it flows continuously (creep). In either case, of course, the metal fails if the stress is increased sufficiently. Fortunately, the rate of creep of a metal above its transition temperature is a function of the applied stress. A negligible amount of creep or change of shape during the life of the part may be achieved either by limiting the applied stress by correct design or, if a high applied stress is unavoidable, by choice of the most creep resistant material available.

APPENDIX

Sources of Data (in addition to as yet unpublished information available at U. S. Steel Corp., Research Laboratory)

I Creep Strength:

Compilation of Available High Temperature Creep Characteristics of Metals and Alloys, A.S.M.E.-A.S.T.M.—1938.

Technical Bull. No. 6-C, Babcock and Wilcox Tube Co.—1938.

"Molybdenum in Steel," Climax Molybdenum Co.—1938.

Technical Data Bull. No. 26. National Tube Co.—1939.

"Digest of Steels for High Temperature Service," Timken Roller Bearing Co.—1939.

The Fabrication of U.S.S. Stainless Steels, Carnegie-Illinois Steel Corp.—1939.

Allegheny-Ludlum Blue Sheets, Allegheny-Ludlum Steel Corp.—1939.

Enduro Stainless Steels, Republic Steel Corp.—1940.

U.S.S. Stainless and Heat Resistant Steels for Petroleum Industry—1940.

"Alloys of Iron and Chromium, Vol. II," Kinzel and Franks—1940.

U.S.S. Stainless and Heat Resistant Steels for Process Industries.

U.S.S. Stainless and Heat Resistant Steel for Plates.

"Influence of Heat Treatment on Creep of C-Mo and Cr-Mo-Si Steel; R. F. Miller, R. F. Campbell, R. H. Aborn and E. C. Wright; *Trans.* A.S.M., Vol. 26, 1938, p. 81.

"The Creep of 17 Low Alloy Steels at 1000°F"; R. F. Miller, W. G. Benz, and W. E. Unverzagt, *Proc. A.S.T.M.*, Vol. 40, 1940, pp. 771-787.

II Tensile Strength:

Houdremont and Schafmeister, *Arch. Eisenhüttenw.*—1934.

Compilation of Available High Temperature Creep Characteristics of Metals and Alloys, A.S.M.E.-A.S.T.M.—1938.

Technical Bull. No. 6-C, Babcock and Wilcox Tube Co.—1938.

"Molybdenum in Steel," Climax Molybdenum Co.—1938.

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Digest of Steels for High Temperature Service, Timken Roller Bearing Co.—1939.

Allegheny-Ludlum Blue Sheets, Allegheny-Ludlum Steel Corp.—1939.

Enduro Stainless Steels, Republic Steel Corp.—1940

III 1941 A.S.M.E. Allowable Working Stress:

A.S.M.E. Code for Unfired Pressure Vessels, Table U 2, (1941 Addenda to A.S.M.E. Boiler Construction Code for Unfired Pressure Vessels).

IV Thermal Expansion:

U. S. Steel Corp., Research Laboratory (unpublished).

V Thermal Conductivity:

"Thermal Conductivity of Irons and Steels and Some Other Metals in the Temperature Range 0 to 600 Degs. C.," S M Shelton and W. H. Swanger, *Trans. A.S.S.T.*, Vol. 21, 1933, pp. 1061-1078.

"The Flow of Heat in Metals," J. B. Austin, A.S.M., 1942.

VI Susceptibility to Oxidation in Air:

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VII Hardness after Air Cooling:

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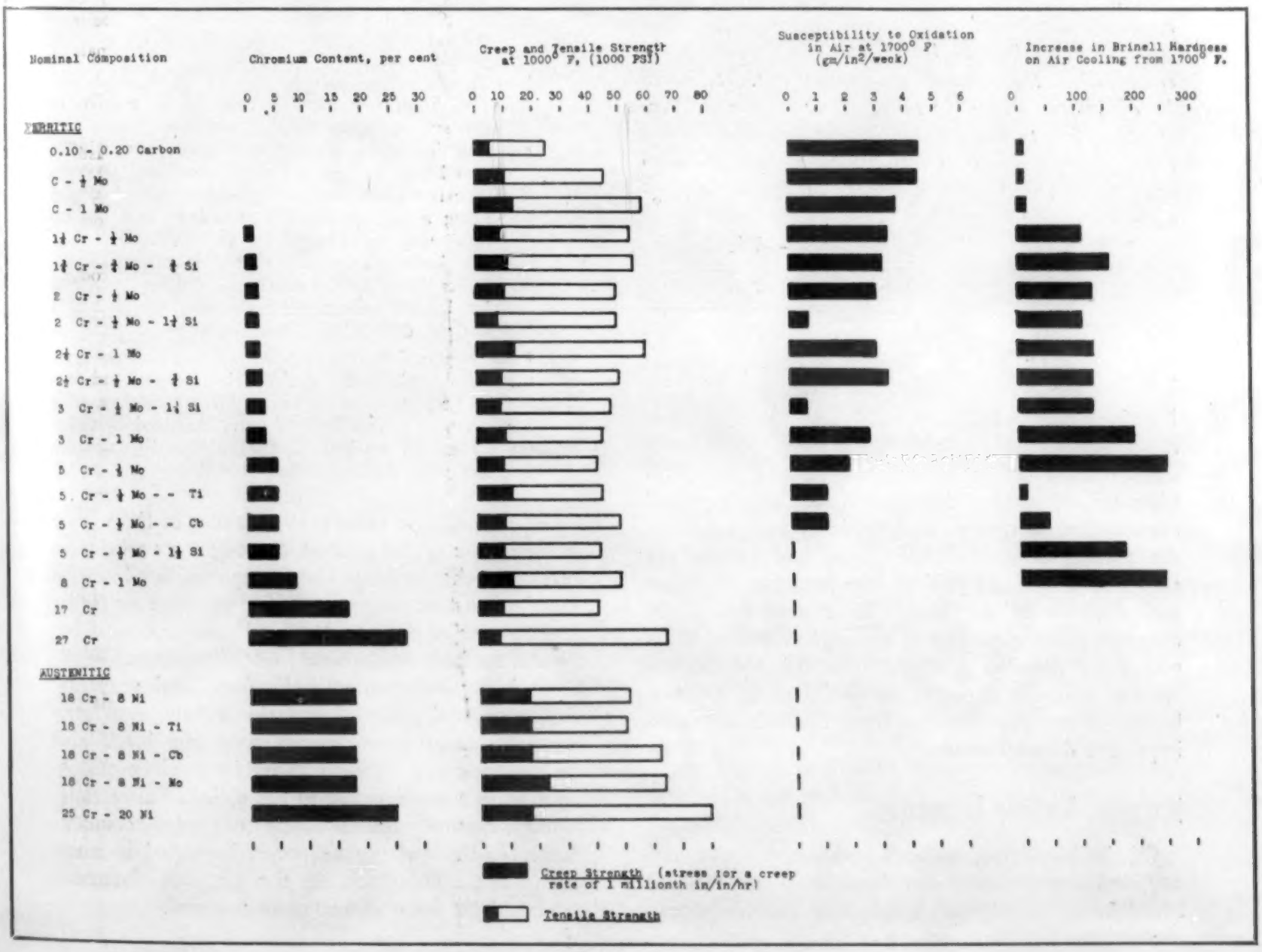
Fig. 8. Influence of composition on creep and tensile strength at 1000 deg. F., on susceptibility to oxidation in air at 1700 deg. F., and on air hardening from 1700 deg. F.


Nominal Composition
Chromium Content, per cent
0 5 10 15 20 25 30
Creep and Tensile Strength at 1000° F, (1000 PSI)
0 10 20 30 40 50 60 70 80
Susceptibility to Oxidation in Air at 1700° F (gm/in²/week)
0 1 2 3 4 5 6
Increase in Brinell Hardness on Air Cooling from 1700° F.
0 100 200 300
FERRITIC
0.10 - 0.20 Carbon
C - ½ Mo
C - 1 Mo
1¼ Cr - ½ Mo
1¼ Cr - ½ Mo - ¾ Si
2 Cr - ½ Mo
2 Cr - ½ Mo - 1¼ Si
2¼ Cr - 1 Mo
2½ Cr - ½ Mo - ¾ Si
3 Cr - ½ Mo - 1¼ Si
3 Cr - 1 Mo
5 Cr - ½ Mo
5 Cr - ½ Mo - - Ti
5 Cr - ½ Mo - - Cb
5 Cr - ½ Mo - 1¼ Si
8 Cr - 1 Mo
17 Cr
27 Cr
AUSTENITIC
18 Cr - 8 Ni
18 Cr - 8 Ni - Ti
18 Cr - 8 Ni - Cb
18 Cr - 8 Ni - Mo
25 Cr - 20 Ni
Creep Strength (stress for a creep rate of 1 millionth in/in/hr)
Tensile Strength

Fluorescent Magnetic Inspection

by W. E. THOMAS

Magnaflux Corp., Chicago

War and the strict quality requirements of aeronautical specifications have widened the already considerable use of magnetic particle inspection, underlining the need for speeding-up the visual examination stage of the test, avoiding misinterpretations and eliminating troubles due to poor color contrast and to inaccessibility of some areas. The engineers who developed the Magnaflux test have now brought forth a new magnetic particle test (called "Magnaglo") based on the use of fluorescence, and said to solve many of the practical problems just mentioned. This article describes the new inspection method and indicates its usefulness as compared to the standard Magnaflux test. It should be of interest not only to production men and inspectors, but to those many design engineers whose material and process selections have to be made with one eye on the ultimate necessity of passing a magnetic inspection.

—The Editors

PRACTICALLY ALL INSPECTION METHODS depend on visual examination by the inspector. The use of rules, dial gauges, micrometers and other measuring devices require the reading of a scale; surface finish testing requires the reading of a Profilometer or similar instrument, or merely visual examination; magnetic analysis inspection relies on the reading of a voltmeter; X-ray and gamma ray radiography depend on the interpretation of lights and shadows of the film. In a similar way the magnetic particle method as accomplished with Magnaflux dry powders and pastes for the wet method requires that the inspector search for those accumulations of the particles that form the indications of important discontinuities.

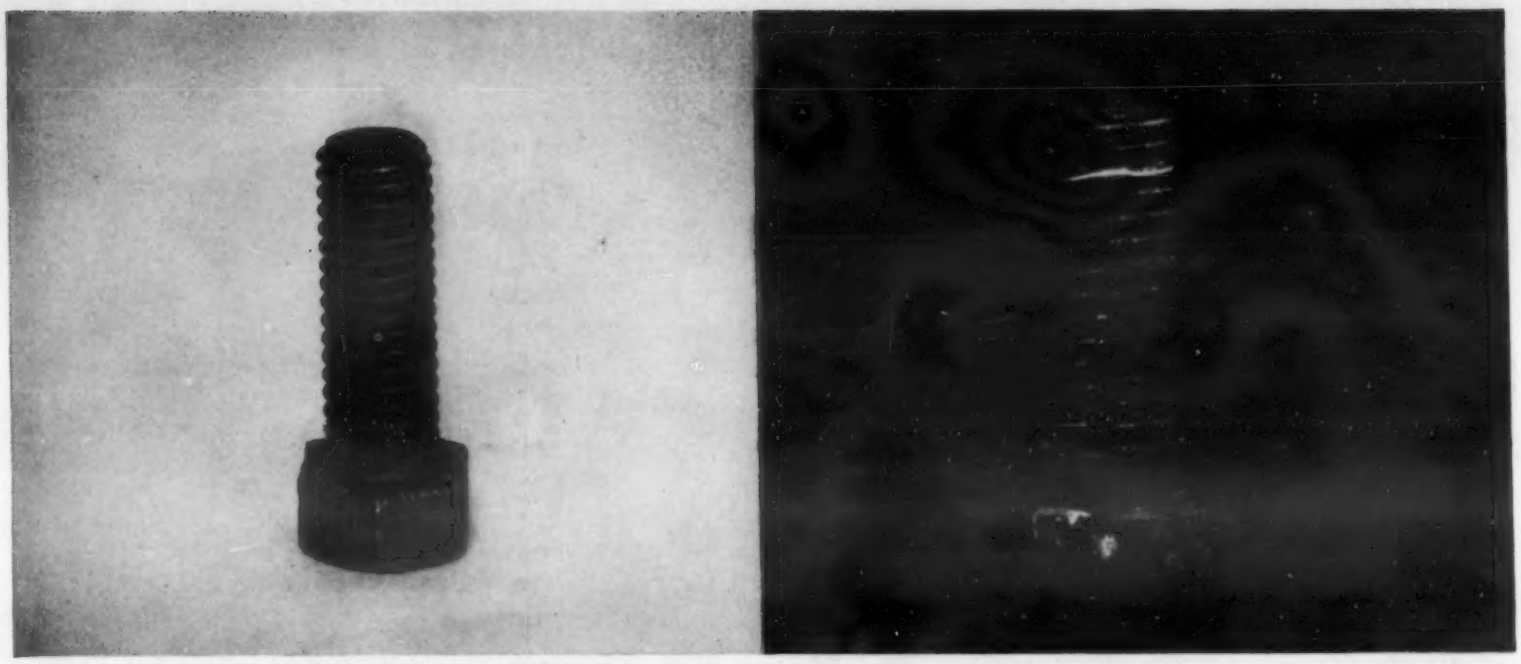
Magnetic Particle Inspection

Of the inspection methods mentioned above, the one requiring the most care, from the purely "visual examination" standpoint, is magnetic particle inspection. There are a number of contributing factors which may be considered:

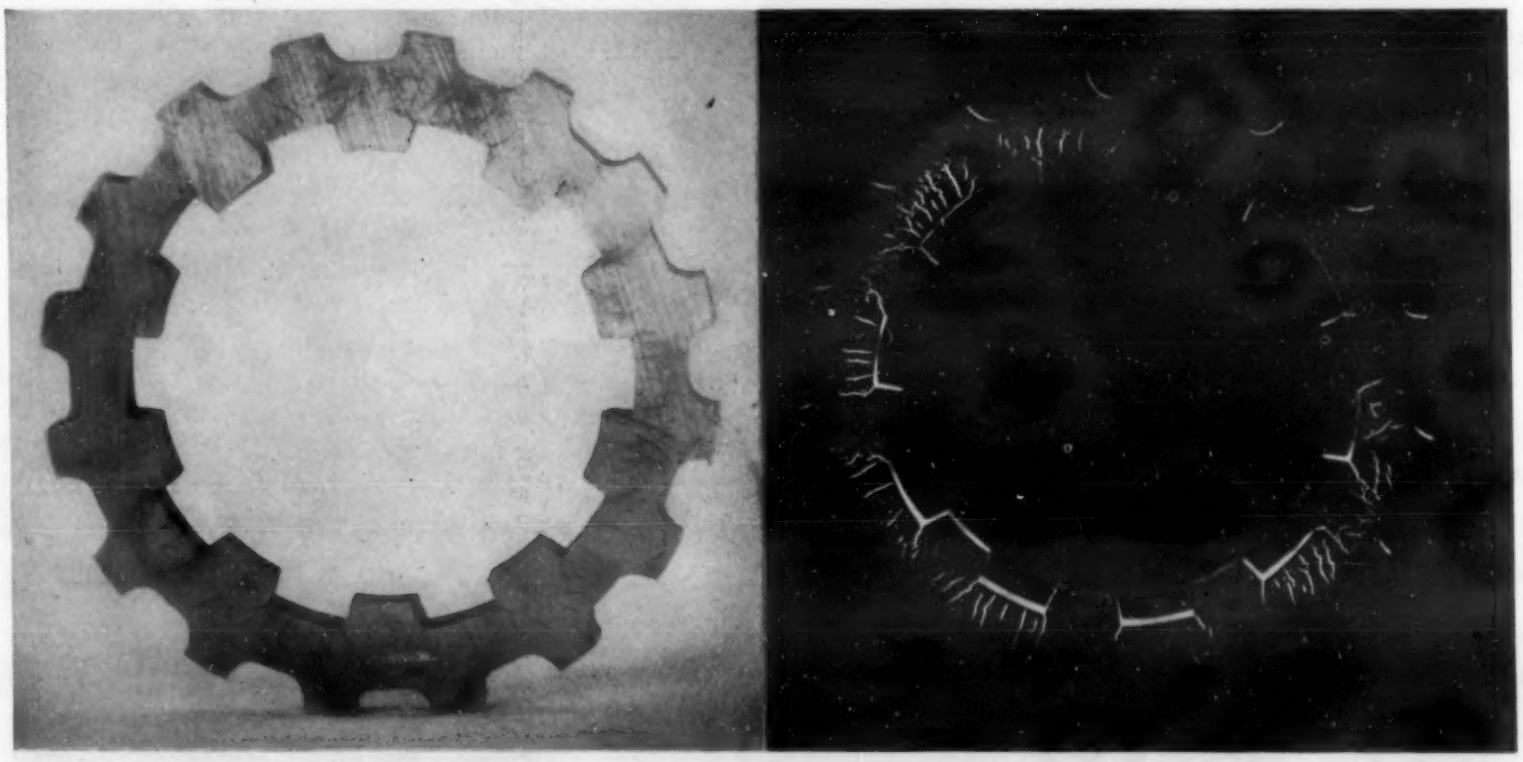
1. The inspector does not know where the indication may be. He must carefully scan the entire surface of the part as he turns it in his hands. He must not pass over any indication either through carelessness, because of fatigue, or because he believes that he has previously examined a certain area.
2. The indication may be extremely small, as small as the cross on the "t" in this type face.
3. The indication may be masked, partly, or wholly, by the following:
   a — The color of the background may be of the same color (or color tone) as the color of the paste or powder particles.
   b — The indication may be parallel to a rough surface finish. It may even lie at the bottom of the surface irregularities.
   c — The indication may extend, partly or wholly, into holes, borings, or deeply machined grooves.
   d — The indication may be masked because it occurs along a line at which a so-called "false indication" may be expected or, in fact, exist.
   e — The indication may be of the wide, fuzzy type, indicative of a sub-surface discontinuity, and may be difficult to interpret because of the lack of a sharply defined line built up by the particles.
4. Parts inspected by the wet method are covered with the light distillate oil used as a suspension medium for the paste particles. This oil film causes disturbing high lights. Highly finished parts inspected by either the wet or dry methods also cause high lights which interfere with the inspectors visions.

Because of these factors, and because of the widely increased use of the method, the engineers who have developed the methods and equipment used, maintained a constant program of research pointing to the development of dry powders, and paste materials for the wet method, which would afford maximum sensitivity, heavy build-up of indications, and visibility.

The original material was the widely used gray powder. Later developments were the black and the red powder. These colors have given industry a wide enough range to solve, in a fairly satisfactory manner, the problem of color contrast. Pastes for the wet method were developed in black and in red. There remains the problem of formulating a light colored wet paste material.



(Left) Bolt with transverse crack in fourth thread from end as shown by Magnaflux wet method. Same bolt (right) with crack shown by Magnaglo wet method.



Splined spacer ring (left) with indications shown by Magnaflux wet method. Same ring (right) with indications shown by Magnaglo wet method.

Fluorescence

Several years ago it first seemed possible that fluorescent (or phosphorescent) indicating particles would be ideal from the standpoint of eliminating most of the problems of the masked, or partially masked indications. Different fluorescent or phosphorescent materials were tried as coating on the powder and paste particles but always one or more adverse factors caused their rejection. One of the main difficulties was the fact that so many of the commonly known compounds with these properties tend to produce cancer, and hence are not suitable for general use. Results were encouraging, however, and the work was carried on slowly. The joining of the knowledge of chemists with considerable background in "fluorescence" and of physicists working with the magnetic particle method resulted in a suitable material for the wet method recently announced under the trade name "Magnaglo." A dry powder is now in the development stage.

There are many whose knowledge of fluorescence and "black" light is limited, and the following para-

graphs will serve to give a working knowledge of these terms.

Fluorescence is a term used to describe the effects produced by certain chemical products that exhibit the peculiar property of emitting visible light from within themselves during activation by "near ultra violet" or "black" light. These materials absorb the invisible energy, alter its wave length and emit the energy in the form of light which the eye can see.

"Black" light is the term popularly applied to the invisible radiant energy in that portion of the ultra-violet spectrum just beyond the blue of the visible spectrum. The visible spectrum ranges roughly between 4000 and 8000 Angstrom units in wave length. The black light range is between 3000 and 4000 Angstrom units in wave length. This black light is not to be confused with the ranges of ultra-violet used for therapeutic, sterilization, germicidal and health purposes, which are below 3000 A.U. and which are potentially harmful to the eye in varying degree.

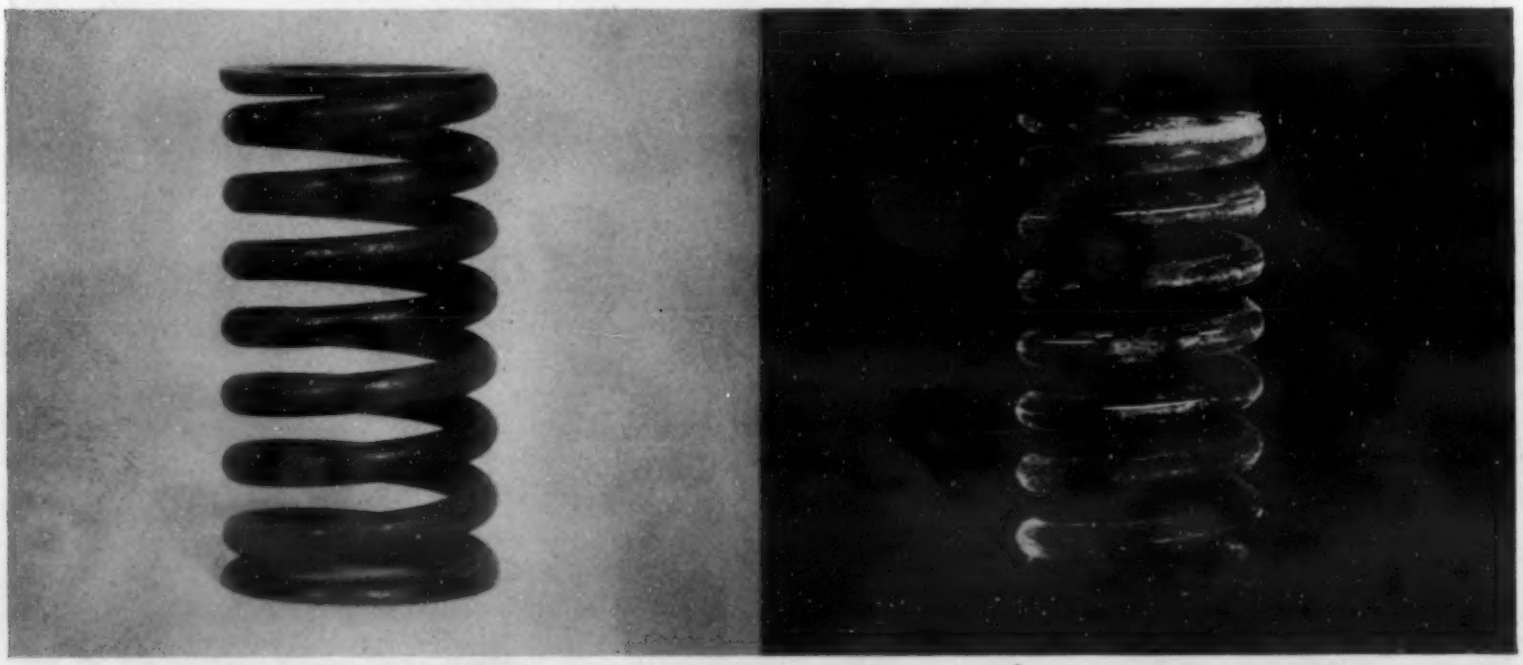
Near-ultra-violet radiations are present in the emission from the sun, the carbon arc, the mercury vapor arc, the iron spark and other sources. It is usually accompanied by some visible light and some infra red (heat). The most potent and practical source is the high-intensity mercury arc, a discharge between two electrodes in an atmosphere of inert gases and mercury vapor. The visible radiations produced are substantially eliminated in black light equipment through the use of an auxiliary filter glass, highly colored to absorb approximately 97 per cent of the visible radiations while passing a maximum of the desired invisible radiations.

Practical Procedure

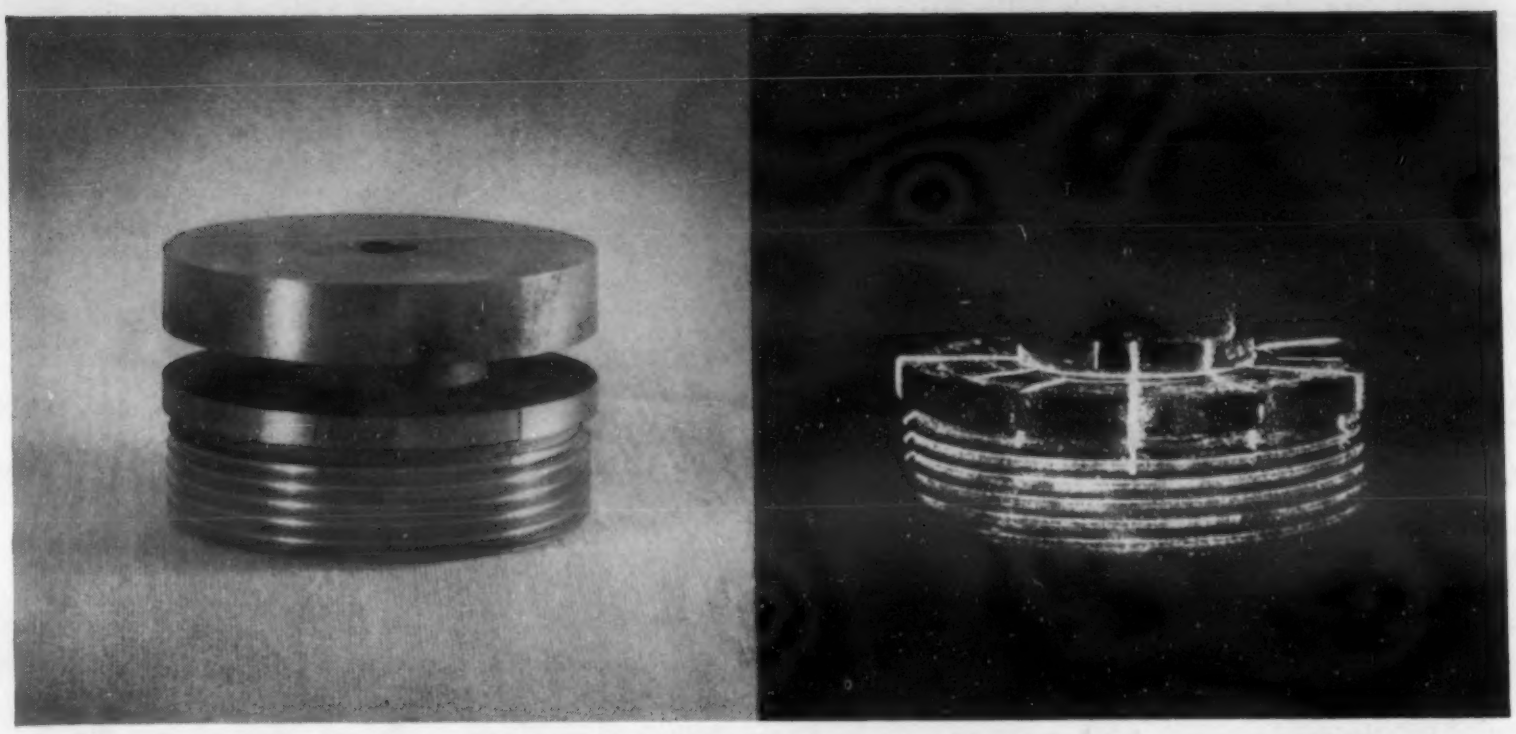
In making up a wet bath for the magnetic particle method, the suspension commonly used is 1 to 1.5 per cent solid particles in the light oil medium. The amount of paste is as large as possible, but small enough to avoid an objectionable overall coating of the part by the paste. Even this 1 or 1.5 per cent suspension leaves a certain amount of particles all over the part, but their extremely small size makes the film practically invisible.

The fluorescent magnetic particles are, however, much more visible under black light than Magnaflux paste particles of the same size under visible light. Therefore, the same 1 to 1.5 per cent suspension of fluorescent paste leaves a very visible, and disconcerting fluorescent film over the part being inspected. It is necessary to reduce the percentage in suspension drastically to eliminate this film. The percentage actually used ranges from 0.2 to 0.3 per cent by volume of paste to volume of oil. This percentage is checked by allowing 100 c.c. of the suspension to stand in a centrifuge type of graduate. After 30 min., the cubic centimeter reading of the solid paste which has settled out of suspension is read.

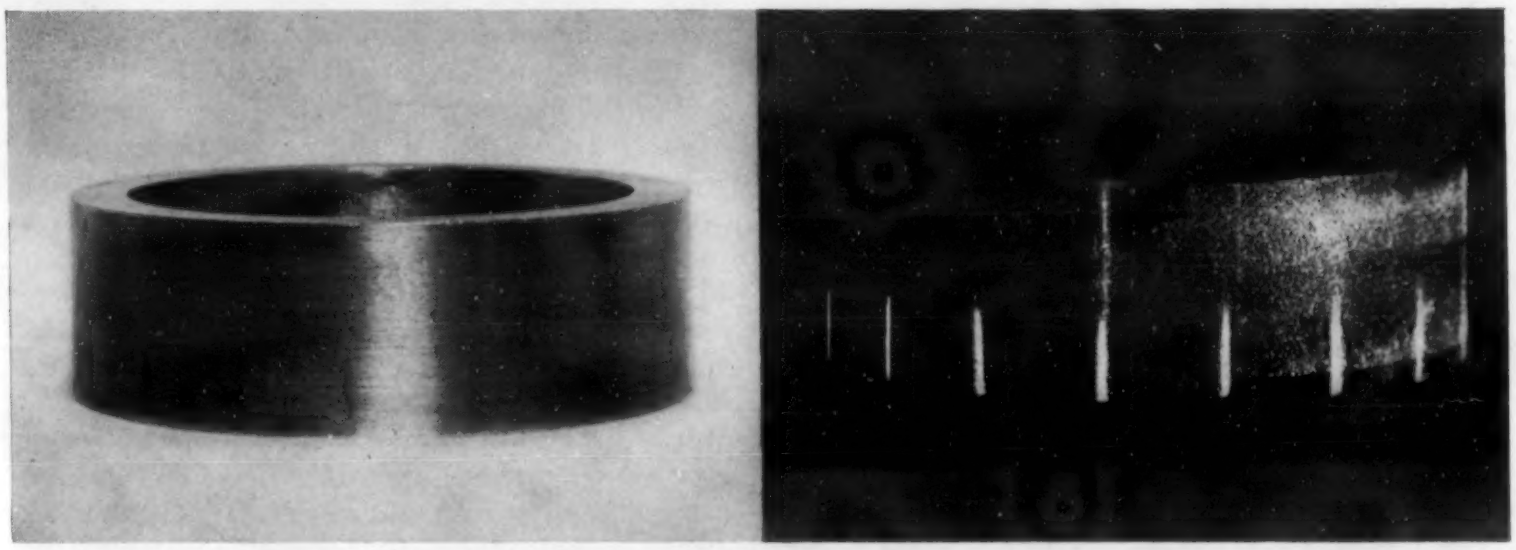
When this small amount of paste is used the indications, while readily visible under black light, are not easily seen under visible light, because the volume of the build-up of the paste particles is very small. If this is objectionable to the inspector, a mixture of the non-fluorescent red paste and the fluorescent material may be used. If this is done, the suspension may be checked by the same settling test that is used to determine the number of cubic centimeters of the mixture of the two pastes, but it will not determine whether a sufficient volume of the fluorescent material is present. This is accomplished easily by keeping a defective part with a very small indication as a test piece, and making a test with this



(Left) Valve spring showing seams as indicated by Magnaflux wet method. Same spring (right) showing indi cations by Magnaglo wet method.



A 37-mm. breech part (left) showing cracks indicated by Magnaflux wet method. Same part (right) with indications shown by Magnaglo wet method.



A 4-in. diameter ring (left) containing small holes drilled into the ring from the lower face. The holes are the same size and are located progressively farther from the outside diameter from left to right in the photograph. The indications are those of Magnaflux. Same part (right) showing indications as developed by Magnaglo wet method. (Above the fourth indication from the left, there is an apparent continuation of the indication which is not shown by Magnaflux. This is apparently the result of a high light and is not a true indication. The negative was not re-touched in any way, and the photograph gives an apparently incorrect indication.)

piece at intervals to determine whether the indication shows up readily with sufficient fluorescence.

Comparison of Methods

As stated before, the purpose of the fluorescent method is to improve the visual inspection operation. Referring back to the factors affecting this operation, when using standard red or black "visible" pastes, we see that they are the following:

1. The necessity of carefully scanning the entire surface.
2. The small size of some indications.
3. Masking or partial masking of the indications by:
   a — Color of background.
   b — Irregular surface finish.
   c — Holes or borings.
   d — False indications.
   e — Relatively small volume of particles over subsurface indications.
4. Strong headlights.

These factors are considerably changed when using the fluorescent paste as outlined below:

1. If the test piece is examined in darkness, any small light source, such as a fluorescent indication attracts

and draws the eye immediately. The size and complexity of the part do not, therefore, offer merely the opportunity to miss the indication as in visible light.

2. The extreme fluorescence of the indications make the visibility, under black light, so high that even very small indications catch the eye.
3. Masking of the indication is eliminated.
   a — Visibility depends upon reflective values. These values may be accurately measured. For example, the reflective value of this white paper is, perhaps 80 per cent. The reflective value of this black ink is, perhaps 4 per cent. Therefore the color contrast of a good white and a good black is approximately 20 to 1. Actually, in magnetic particle inspection, the contrast between the background and the indication may be only a small fraction of this ratio. If we are in absolute darkness, then even a very, very small light source gives a contrast of infinity. Actually we do not usually inspect in absolute darkness, but with sufficient visible light so that the outline of the part is visible. Even so, the contrast between the very dark surface and the glowing indication is much greater than the usual ratios when using the usual black or red pastes available.

   b — For the same reasons given above, surface finish does not disturb the inspector as he looks only for a brilliant line or indication, and not for a contrast between the indication and the surface of the part.

   c — As the indication forms its own visible light rays, the inspection of holes or borings can be much easier as it is frequently difficult to project a visible light into the hole and yet have the eye in a favorable position to view the indication.

   d — False indications, particularly those caused by leakage fields at sharp corners and changes of section are much reduced by the use of the fluorescent method. The greatly reduced volume of paste particles in suspension is not conducive to heavy build-up in weak fields. The reduced volume of particles also results in a cleaner washing off of the surface of the part. Thus, the fluorescent method allows the inspection of threaded parts, and of corners where such areas have been quite difficult to examine with Magnaflux pastes unless the indication was large.

   e — Sub-surface discontinuities cause weaker external leakage magnetic fields than surface defects because of the much greater permeability of the iron or steel over the discontinuity. These leakage fields extend over a much larger area than those caused by a surface crack or seam. For these reasons the extremely small ferromagnetic particles in paste form do not build up well into sharp clearly defined heavy indications. Many indications are actually formed with these pastes that are not located by the inspector purely because they appear the same as many other areas of the surface of the test piece which have a light visible accumulation of particles. The fluorescent particle indications on the other hand can be seen under black light when the same non-fluorescent particle indication is not noticeable in visible light.

4. The question of visible light highlights does not, of course, seriously enter into the inspection under black light. The highlights, or reflections from the part are all of the near ultra violet, or invisible range.

The accompanying photographs illustrate some of the most important differences between visible red paste and fluorescent paste indications. Those taken of the red paste indications were taken under visible light and in all cases were lighted so that the indication would appear as distinctly as possible. Those taken of the fluorescent indications were taken under ultra violet light.

In conclusion—the fluorescent method appears to be capable of speeding up the most time-consuming part of this magnetic particle inspection method, that of visual examination; avoiding many of the troubles due to false indications and highlights, and eliminating difficulties of color contrast and inspection in hard-to-see areas. The material was disclosed, early in its development, to the Army Air Force and Navy Bureau of Aeronautics, and they have followed its development with interest.

This material should not be confused with the new "black light" inspection method also recently announced by the Magnaflux Corp. under the trade name of "Zyglo." Zyglo is an entirely different, *non-magnetic* inspection method particularly suited for the detection of cracks and other surface discontinuities in aluminum, magnesium, austenitic steels and other non-magnetic materials. It employs fluorescent liquid penetrants and black light, and the indications look similar to those formed by Magnaglo, but there the similarity ends.

The Properties of Pure Nickel—II

The first instalment of this compilation of engineering and physical properties of nickel appeared in METALS AND ALLOYS *for September, and was devoted to "very pure" nickel. The present instalment provides data on commercial wrought "A" nickel. The concluding instalment will cover the effect of alloy additions on electrolytic nickel.* —*The Editors*

BY E. M. WISE and R. H. SCHAEFER

Staff Advisor and Metallurgist, respectively Research Laboratory, International Nickel Co., Bayonne, N. J. [Present addresses, International Nickel Co., 67 Wall St., New York and Amer. Manganese Steel Co., Chicago Heights, Ill., respectively]

"A" nickel, the commercially available wrought nickel, is produced by melting electrolytic nickel and adding thereto minimal quantities of deoxidizing and sulphur fixing elements to secure a sound malleable product which will withstand considerable abuse in processing. This type of nickel has uses ranging from coinage, caustic evaporators, radio and sign tube electrodes, as the base for gold filled spectacle frames to storage tanks, resin kettles and special heat-treating fixtures where such properties as color, corrosion resistance, moderate strength and good fabricating and welding properties are essential.

The strength of "A" nickel is higher than that of nickel of academic purity and the electrical, magnetic and thermal properties are slightly different. For most other properties the data presented in the previous section on Pure Nickel can be considered applicable to "A" nickel as well.

Composition and Properties of "A" Nickel

The nominal composition of "A" nickel is:

	Per Cent		Per Cent
Nickel (plus Co) ..	99.4	Carbon	0.1
Copper	0.1	Silicon	0.05
Iron	0.15		
Manganese	0.2	Sulphur	0.005

Melting range: 1435 to 1445 deg. C.
Crystal form: Face-centered cubic at all temperatures.

Density—
Cold drawn, 20 per cent 8.884 gms. per cu. cm. at 20 deg. C.
Hot rolled ..... 8.887 gm. per cu. cm. at 20 deg. C.[31]
C.D. annealed ..... 8.885 m. per cu. cm. at 20 deg. C.

The analysis of this material is the same as shown for Fig. 8

1. THERMAL PROPERTIES:

The specific heat (cal $g.^{-1}$ deg. $C.^{-1}$) is (Sample containing 0.03% Mn; 0.19% Si; 0.15% Fe; 0.45% Co).

0.1128 at 100 deg. C.[31]
0.1240 at 200 deg. C.[31]
0.1386 at 300 deg. C.[31]

The coefficient of thermal expansion (Average of two annealed samples) is:

13.3×10^{-6} 25-100 deg. C.[32]
14.5×10^{-6} 25-300 deg. C.
15.55×10^{-6} 25-600 deg. C.

The thermal conductivity (in gm. cal $sec.^{-1}$ $cm.^{-2}$/deg. C. $cm.^{-1}$) is

0.155 at 100 deg. C.[33]
0.143 at 200 deg. C.[33]
0.131 at 300 deg. C.[33]
0.125 at 400 deg. C.[33]
0.130 at 500 deg. C.[33]
0.136 at 600 deg. C.[33]

(Sample contained Cu. 0.14%; Mn 0.09%; Fe 0.6%.)

2. ELECTRICAL PROPERTIES:

The electrical resistivity is:
9.0-10.5 microhm cm. at 20 deg. C.[34]
54-63 ohm/circular mil. ft. at 20 deg. C.[34]

The temperature coefficient of electrical resistivity is:
0.005 to 0.0043/deg. C., 20 to 100 deg. C.[34]

(See Fig. 7 for relation between resistivity and temperature coefficient.)

3. MECHANICAL PROPERTIES:

The modulus of elasticity (Young's Modulus) is:
30,000,000 lbs. per sq. in.[34]

The modulus of elasticity in torsion is:
11,000,000 lbs. per sq. in.[34]

Poisson's ratio (average) is: 0.31[35]

The fatigue ratio: $\frac{\text{Fatigue strength 100,000,000 cycles}}{\text{Tensile strength}}$

0.31 to 0.42[36,37] for material covering a considerable range of strengths.

Impact properties—45-deg. Vee notch Charpy in ft. lbs.[31]

	R. T.	—112 deg. F.	—310 deg. F.
Hot-rolled	195	236	227
Cold-drawn (outside)	190	236	208
Cold-drawn (center)	185	205	210
Annealed at 1400 deg. F.....	216	236	234

Tensile Properties:

By suitable choice of hot rolling, annealing and cold drawing or rolling processes, tensile strengths ranging from 65,000 to 115,000 lbs. per sq. in. can be had in rods and bars, as high as 130,000 lbs. per sq. in. in strip and 160,000 lbs. per sq. in. in wire, while over 200,000 lbs. per sq. in. can be had in the specially alloyed "Z" nickel wire.

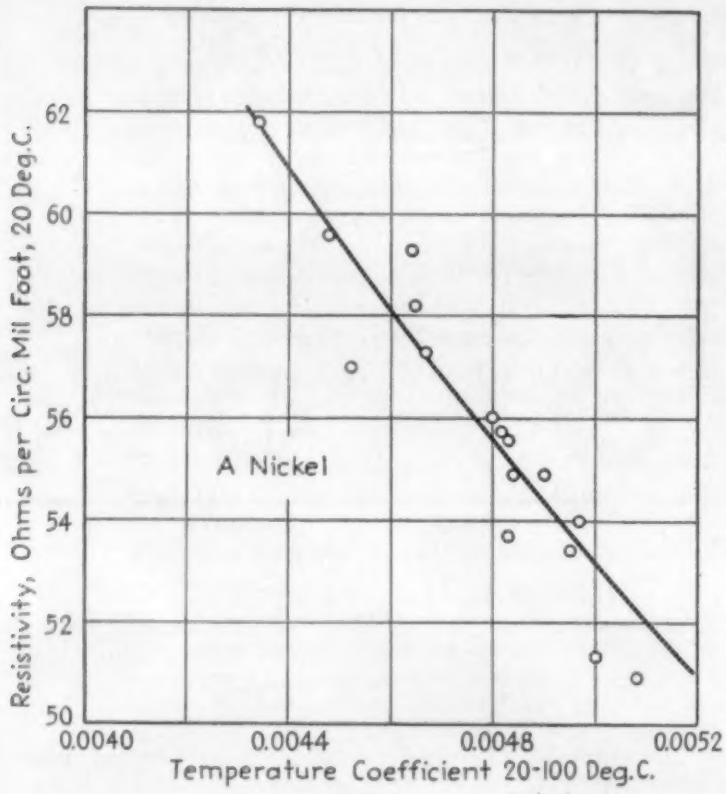


Fig. 7. (Above) Relation between resistivity and temperature coefficient.

Brinell hardnesses within the range 90 to 200 can be had in rods and bars.

Fig. 8[34] shows the effect of cold rolling upon the Vickers hardness of a sample of annealed "A" nickel having the following analysis:

	Per Cent		Per Cent
Ni + Co	99.53	Iron	0.13
Carbon	0.08	Copper	0.07
Silicon	0.03	Sulphur	0.005
Manganese	0.13		

It is of interest to note that between 25 to 90 per cent cold reduction, where the rate of work hardening is substantially constant, one per cent of cold reduction increases the Vickers hardness 1.5 points.

The effect of annealing for 1 hr. upon the hardness of samples of the above "A" nickel, given 50 and 90 per cent reduction are shown in the same figure,[34]

For further details concerning working and annealing see reference[35]

Tensile strength of hot-rolled "A" nickel at elevated temperature is shown in Fig. 9[37].

Torsional strength, cold-drawn 1-in. diameter "A" nickel is:

Maximum torsional moment	21,400 in. lb.[34]
Breaking strength	81,400 lbs. per sq. in.[34]
Johnson's apparent elastic limit (in torsion)	63,000 " " " "[34]
Proportional limit (in torsion)	47,800 " " " "[34]
Twist	341 deg. per in.[34]

(To be concluded)

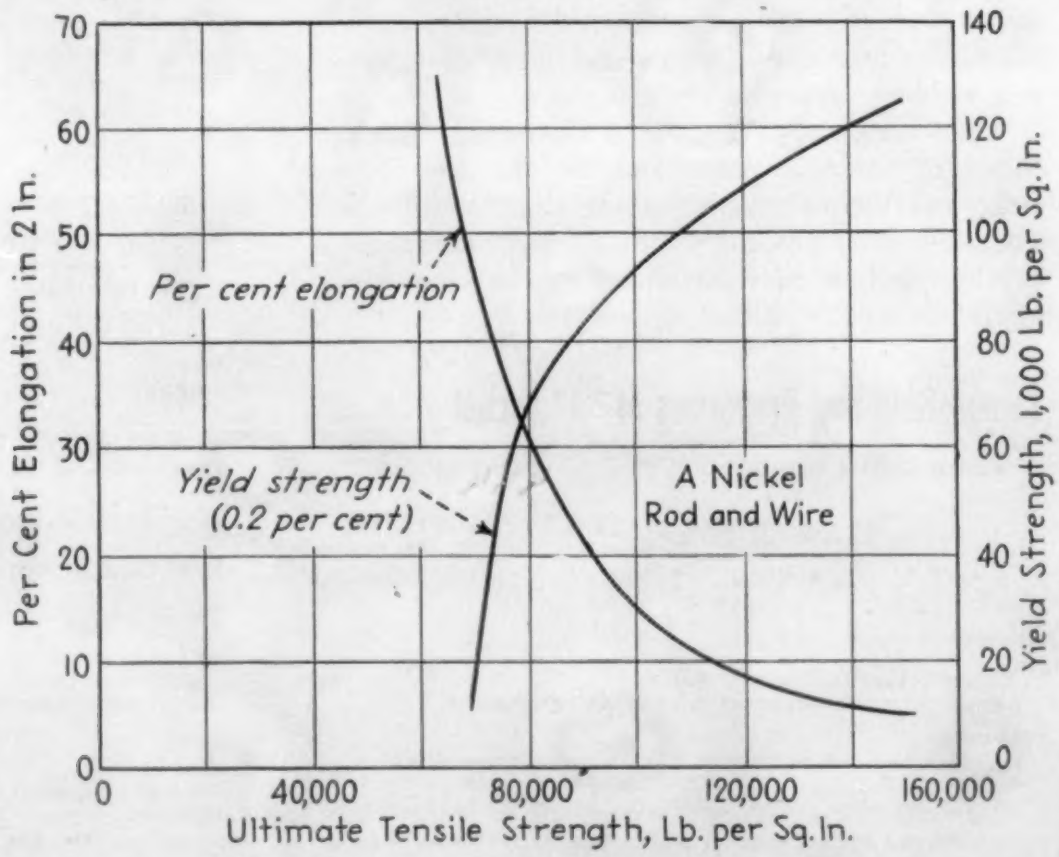


Fig. 8. Approximate relationship between tensile strength, yield strength and per cent elongation.

Table of Mechanical Properties of the More Commonly Employed Forms of Wrought Nickel

Form and Condition	Yield Strength (0.20% offset), 1000 p.s.i.	Tensile Strength, 1000 p.s.i.	Elongation in 2 in., per cent	Red. of Area, per cent	Hardness Brinell, 3000 kg.	Hardness Rockwell B
Wire,						
Cold-drawn,						
Annealed	15-30	60-80	50-30	....	....	....
Regular-temper	90-130	105-140	15-4	....	....	....
Rod and Bar,						
Cold-drawn,						
Annealed	15-30	60-80	50-35	75-60	90-120	40-65
As-drawn	40-90	65-115	35-15	70-50	125-230	70-100
Hot-rolled	15-30	65-80	50-35	75-60	90-120	40-65
Plate,						
Hot-rolled,						
As-rolled	20-75	70-100	45-30	....	100-200	50-100
Sheet, Strip and Tubing						
Annealed	15-30	60-80	50-35	....	....	40-70

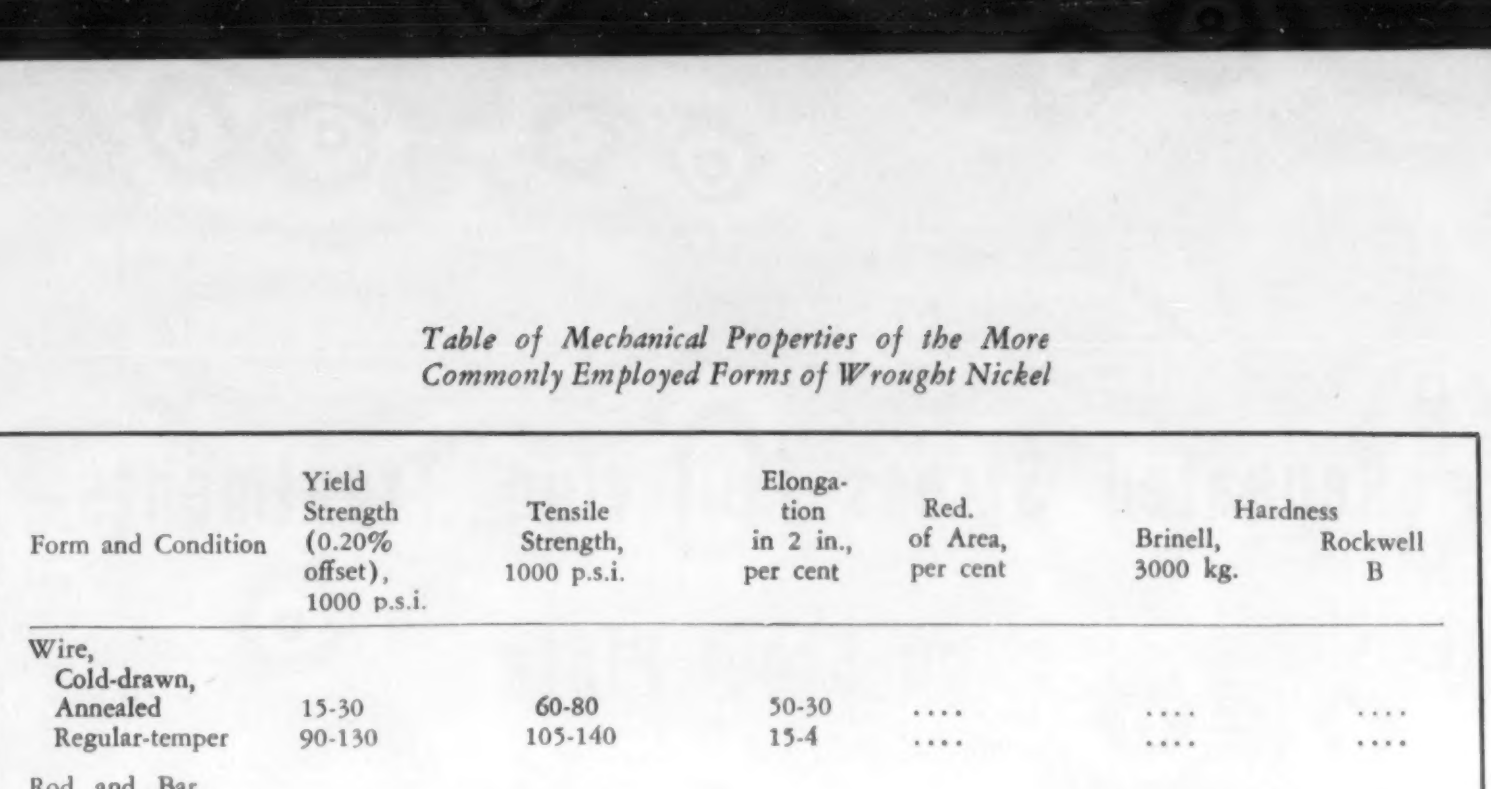


Fig 9. Tensile properties of hot-rolled nickel at elevated temperature.

Repeated Stress Relieving Treatments on Steel Plate

In heavy structural fabrication, it is often necessary to stress-relief-anneal the unit more than once between the beginning of fabrication and its completion. A frequently raised question is: How often can such stress-relieving treatments be repeated without lowering the room-temperature mechanical properties below the minimum values given in the Boiler Code Specifications? The authors demonstrate in this article that the room temperature properties are not appreciably lowered by up to 10 repeated treatments, and the creep resistance by up to 5.

—The Editors

by F. EBERLE AND T. BRICK

Babcox & Wilcox Co., Barberton, Ohio

THE METHOD OF FABRICATION of some structures requires intermediate stress-relieving treatments. Consequently, the question has been raised as to how often a given stress-relieving treatment for a given material can be repeated without lowering the room temperature mechanical properties of the material involved below the minimum values stipulated by the A.S.T.M. and A.S.M.E. Boiler Code specifications.

Materials Investigated

The following five materials and stress-relieving temperatures were used:

1. 65,000 tensile strength plate, 1 in. thick. 1,125 deg. F.
2. 70,000 tensile strength plate, 4 in. thick. 1,125 deg. F.
3. Carbon-molybdenum steel plate, 1 in. and 4 in. thick. 1,200 deg. F.
4. Manganese-vanadium steel plate, 13/16 in. thick. 1,-200 deg. F.

The specified and the actual room temperature properties of these materials are given in Tables 1 to 5. The 4-in. thick carbon-molybdenum steel plate is shown to be higher in silicon content than specified, but otherwise met the specified requirements, as did all the other steels.

Effect of Treatments on Properties

Each of the steels employed was subjected to ten stress-relieving treatments at the temperatures employed in actual fabrication. The initial or standard treatment consisted of holding the material at the prescribed temperature for 1 hr. per in. of thickness. This cycle was successively repeated up to 10 times for each material and different plate thickness. The tensile and impact properties of each steel and of each condition were determined with four test specimens. For the determination of the yield points the drop of beam method was employed. The results of these experiments and tests, which are plotted in Figs. 1 to 5, show:

1. The yield point of the 1 in.-65,000 tensile plate, 4 in.-70,000 tensile plate and 4 in.-C-Mo steel plate remained practically unaffected up to 10 repeated stress-relieving treatments. The yield points of the 1-in.-C-Mo steel plate and the 13/16 in.-Mn-V steel plate decreased by approximately 15 and 7 per cent respectively during the first seven stress-relieving treatments, after which they remained practically constant. They did not drop below the specified minimum value (see Fig. 1). The initial yield point of the 4 in.-70,000 tensile plate was very close to the specified minimum value and in two instances fell slightly below the latter.

2. The tensile strength of all materials showed a decrease with increasing stress-relieving time. This decrease was lowest for the 65,000 and 70,000 tensile plate (see Fig. 2). The tensile strength of the 70,000 tensile plate, 1 in.-C-Mo steel plate and 4 in.-Mo steel plate fell slightly below the specified minimum value after three to five stress-relieving cycles.

3. The elongation, with the exception of the 1 in.-C-Mo steel, increased slightly with increasing stress relieving time.

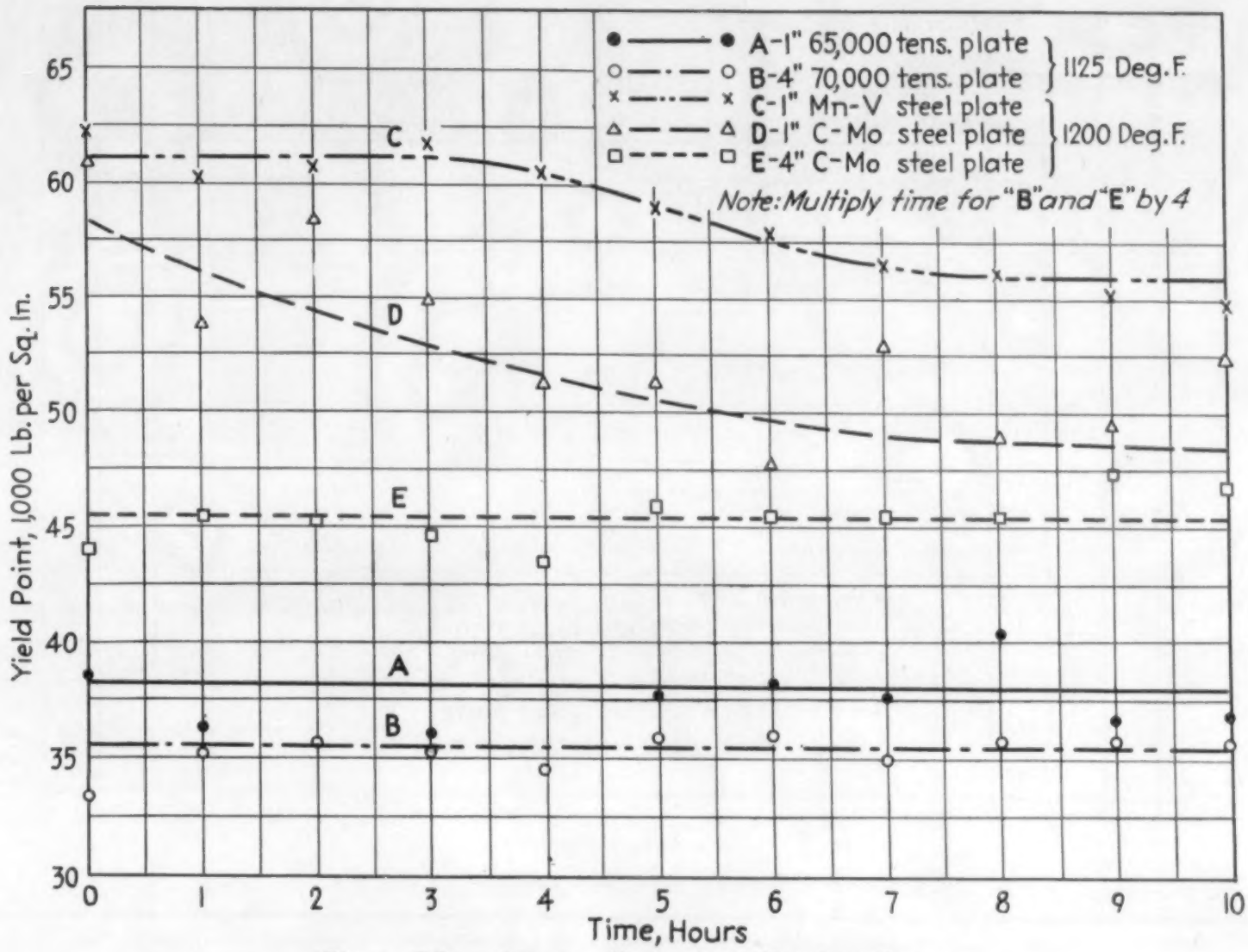
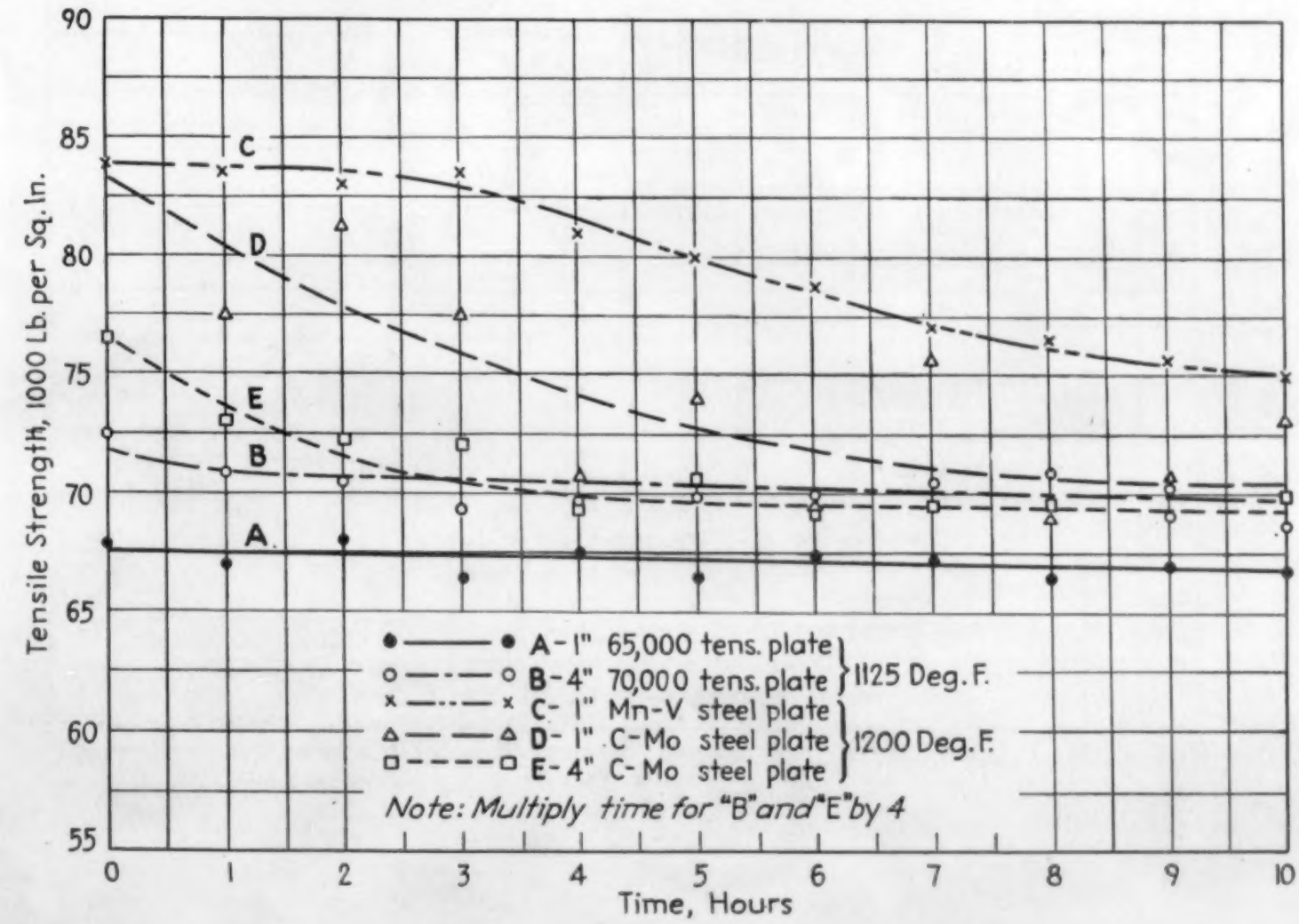


Fig. 1. Effect of stress relieving in yield point values.

Fig. 2. Effect of stress relieving on tensile strength values.



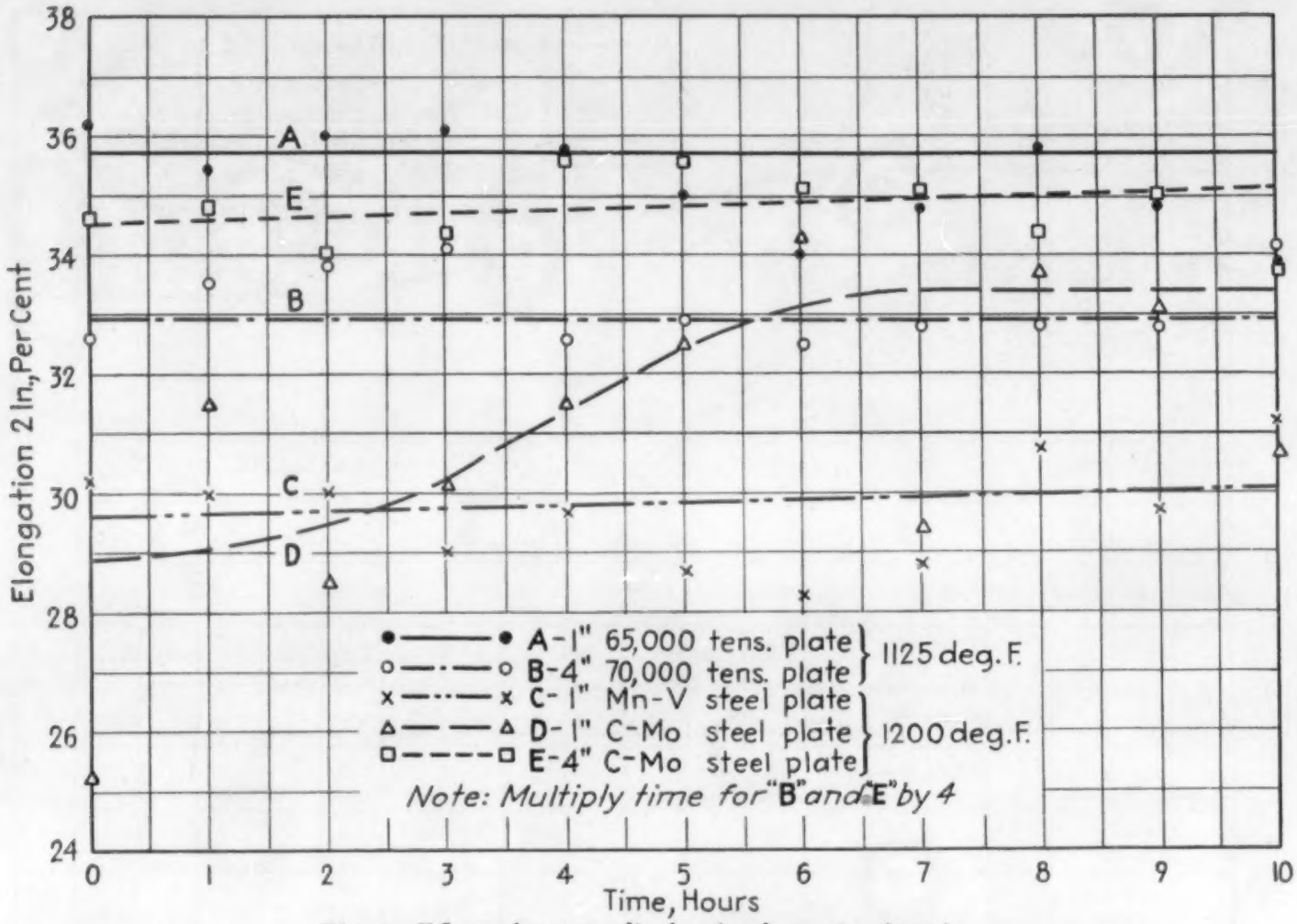
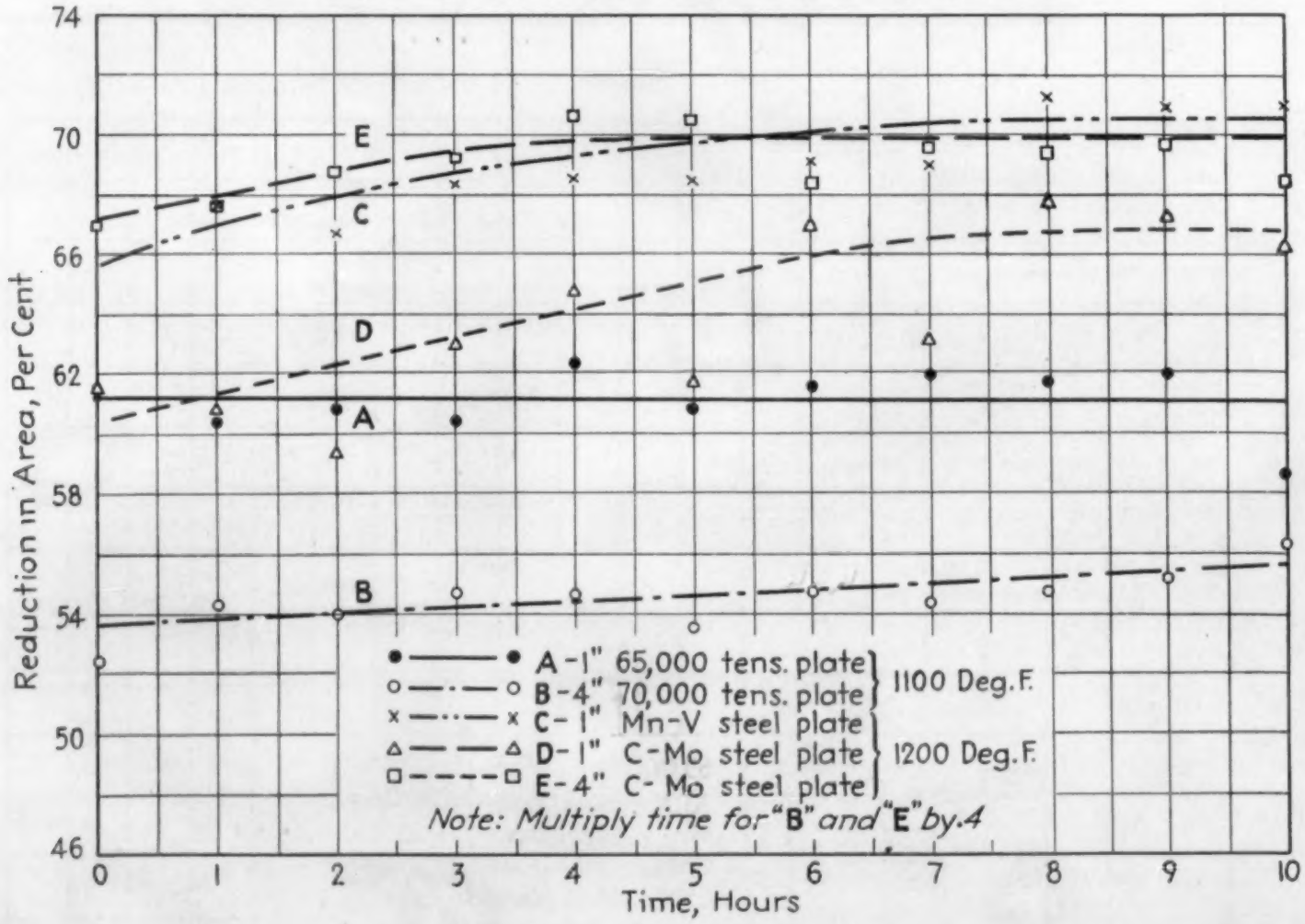


Fig. 3. Effect of stress relieving in elongation in 2 in.

Fig. 4. Effect of stress relieving on reduction of area.



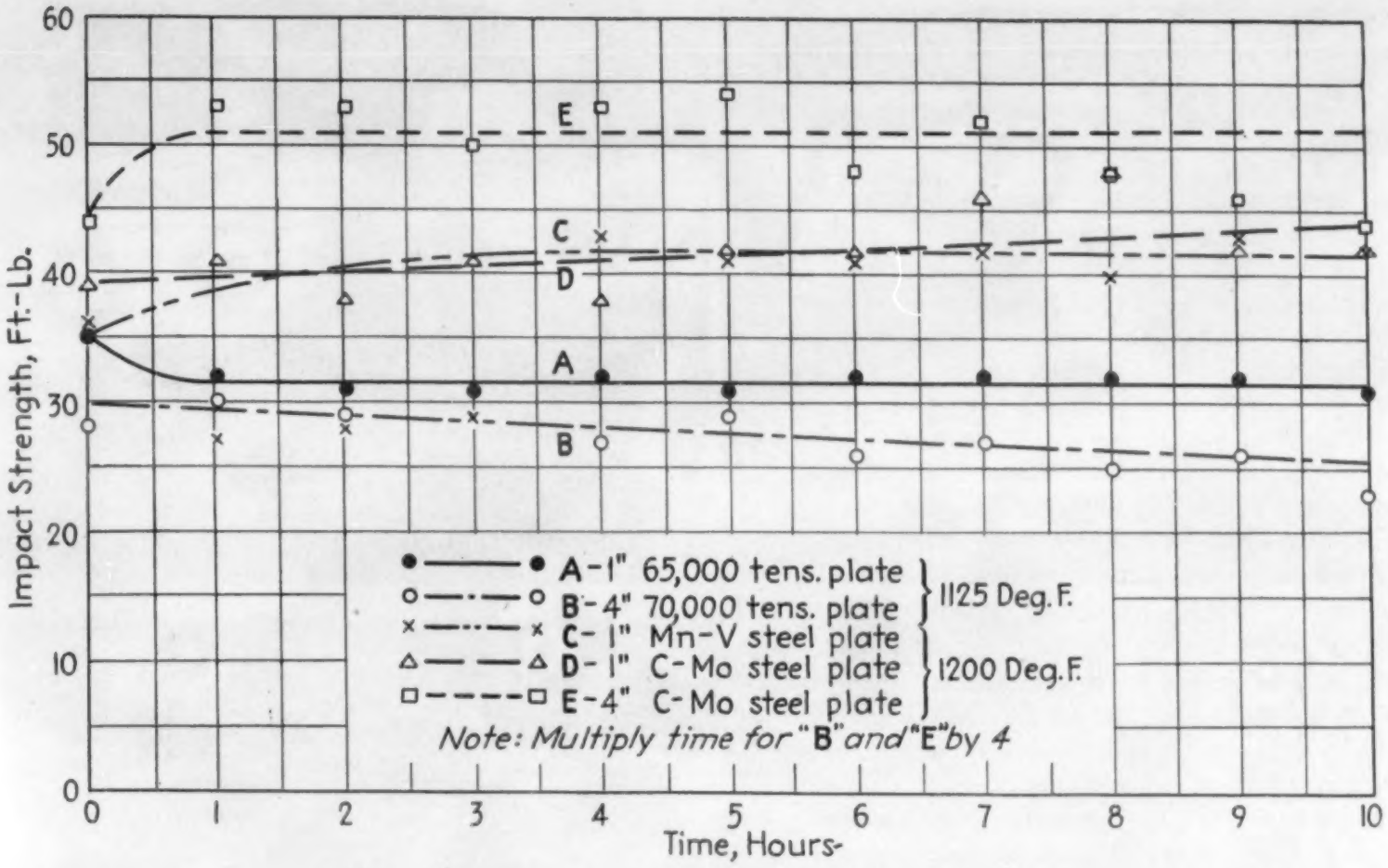

Impact Strength, Ft.-Lb.
Time, Hours-
A-1" 65,000 tens. plate
B-4" 70,000 tens. plate
C-1" Mn-V steel plate
D-1" C-Mo steel plate
E-4" C-Mo steel plate
1125 Deg. F.
1200 Deg. F.
Note: Multiply time for "B" and "E" by 4

Fig. 5. Effect of stress relieving on Charpy impact values.

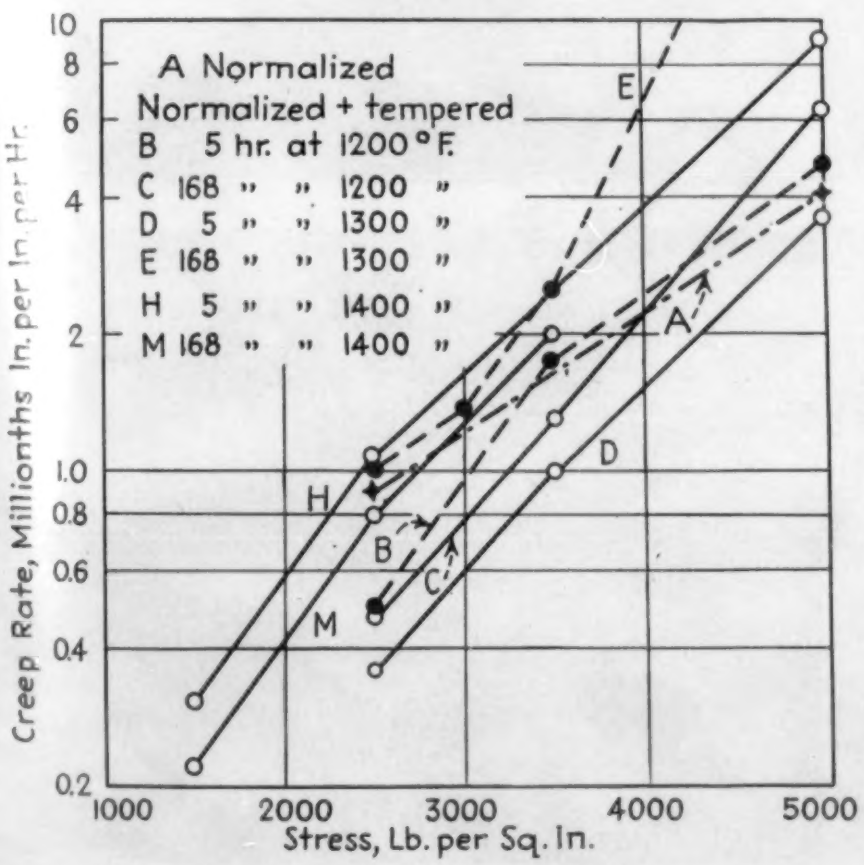

A Normalized
Normalized + tempered
B 5 hr. at 1200° F.
C 168 " " 1200 "
D 5 " " 1300 "
E 168 " " 1300 "
H 5 " " 1400 "
M 168 " " 1400 "
Creep Rate, Millionths In. per In. per Hr.
Stress, Lb. per Sq. In.

Fig. 6. Influence of heat treatment on creep of 0.11 C, 0.54 per cent Mo steel at 1,100 deg. F., semi-log representation.

The increase in elongation of the 1 in.-C-Mo steel plate was more pronounced than that of the other materials (see Fig. 3).

4. The reduction of area of the 65,000 tensile plate and of the 70,000 tensile plate increased only slightly with increasing stress-relieving time, while the increase of those of the other three materials was more marked (see Fig. 4).

5. The Charpy impact values of the 65,000 tensile plate remained practically constant after a slight initial drop, those of the 70,000 tensile plate showed a slight uniform decrease and those of the other three steels a slight uniform increase (see Fig. 5).

Effect of Treatments on Microstructures

The change in the microstructures produced by prolonged stress-relieving treatments is illustrated by Figs. 7 to 11. All steels show progressive spheroidization of carbides with increasing stress-relieving time. The two C-Mo steels appear to display a greater resistance to carbide spheroidization than the three other materials. The Mn-V steel seems to possess the highest rate of spheroidization. It should be remembered that the temperature used on the C-Mo and Mn-V steels was 75 deg. higher than on the carbon steels. In general, the results indicate that up to about four stress-relieving treatments the spheroidization of the carbides has not progressed far enough so as to seriously impair the creep resist-

ance of the materials. This holds true of the 1 in. thick material as well as of the 4 in. thick material.

Discussion

The experimental results presented indicate that stress-relieving treatments may be repeated up to 10 times without danger of appreciably lowering the room temperature mechanical properties of the materials under consideration below the minimum values stipulated by Boiler Code specifications. More important appears to be the effect of repeated or prolonged stress-relieving treatments upon the creep properties of the materials. The temperatures involved produce progressive spheroidization of carbides. After about four to five stress-relieving treatments coalescence of carbides, which is known to lower the resistance to creep under certain conditions, becomes noticeable.

The potential effect of spheroidization upon the creep resistance is brought out by the diagram of Fig. 6, given by Miller and co-workers, which shows the influence of heat treatment on creep of a carbon-molybdenum steel at 1100 deg. F. The interesting fact brought out by this diagram is that under certain conditions a spheroidized structure may have a better creep resistance than a normalized structure up to a certain stress. In the light of the available knowledge on this subject and on the basis of the experimental results presented, it appears that about five stress-relieving treatments may be applied to a structure without appreciably lowering the room temperature mechanical properties or the creep resistance of the materials involved. It is also advisable to keep the temperature of stress-relieving as low as possible. This applies particularly to intermediate stress-relieving treatments.

Table 1—Specified and Actual Properties of 1 in.-65,000 Tensile Strength Plate

Boiler Code Specifications: A.S.T.M.—A-201-39; A.S.M.E. —S42, "Carbon Silicon Steel Plates of Ordinary Tensile Ranges for Fusion-Welded and Other Pressure Vessels."

	Specified Item	*Specified Value*	*Actual Value*
Analysis	Carbon	0.24 max.	0.25
	Manganese	0.80 max.	0.57
	Silicon	0.15-0.30	0.16
	Phosphorus	0.035 max.	0.015
	Sulphur	0.035 max.	0.027
Tensile Properties	Yield Point, lbs. per sq. in.	30-35,000	38,400
	Tensile Strength, lbs. per sq. in.	60-70,000	67,800
	Elongation in 2 in., per cent	29 to 25	36

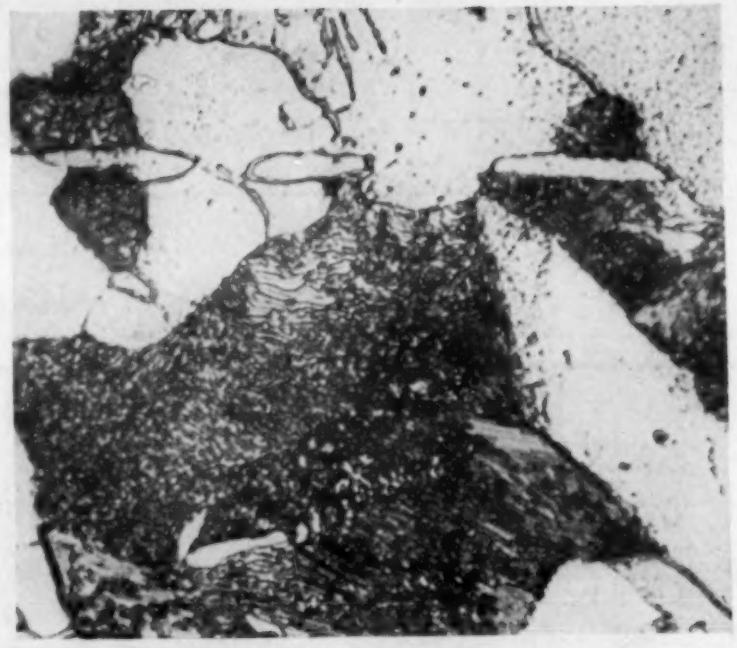
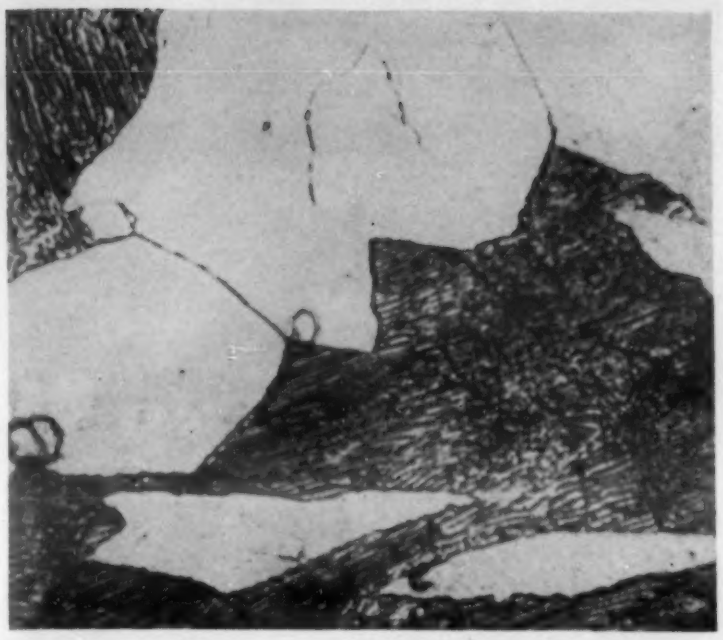
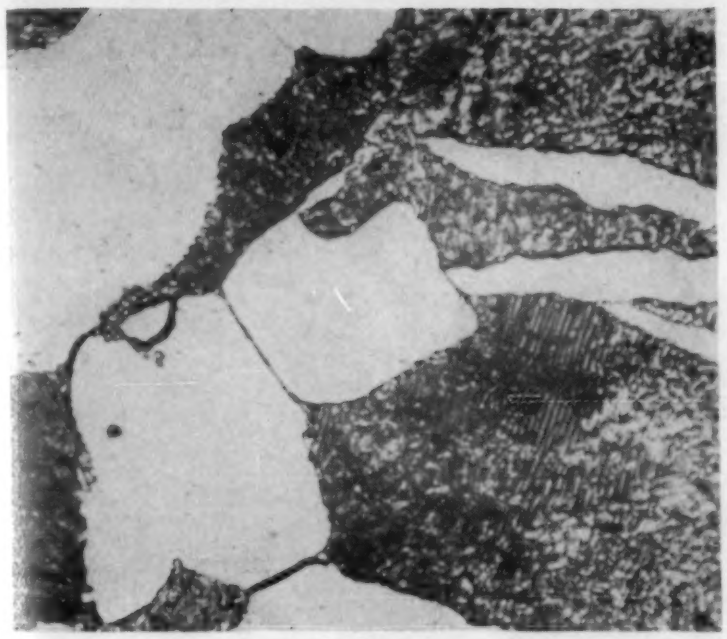


Fig. 7. Structures of the 65,000 tensile carbon steel, 1 in. thick. Top, as received; center, after 4 hrs. at 1,125 deg. F.; and bottom, after 8 hrs. at 1,125 deg. F. All etched with nital. Each one 1,000X.





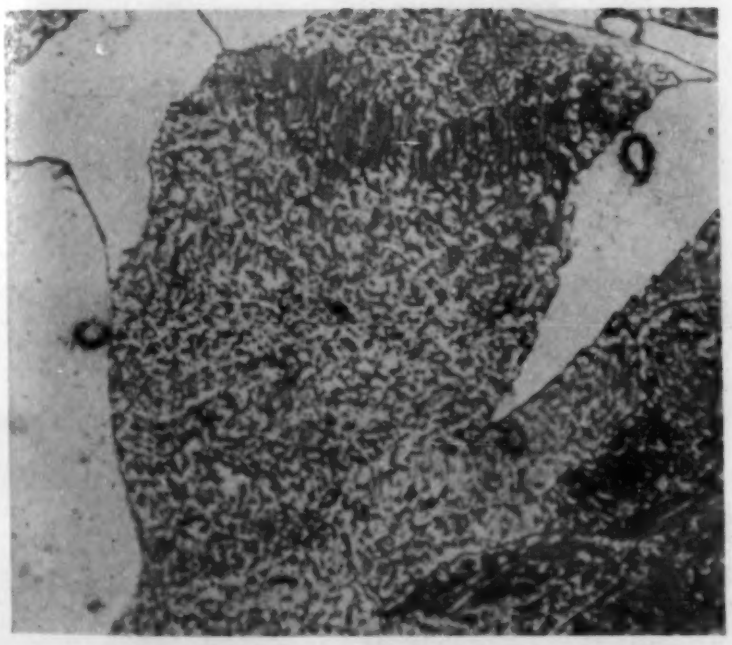
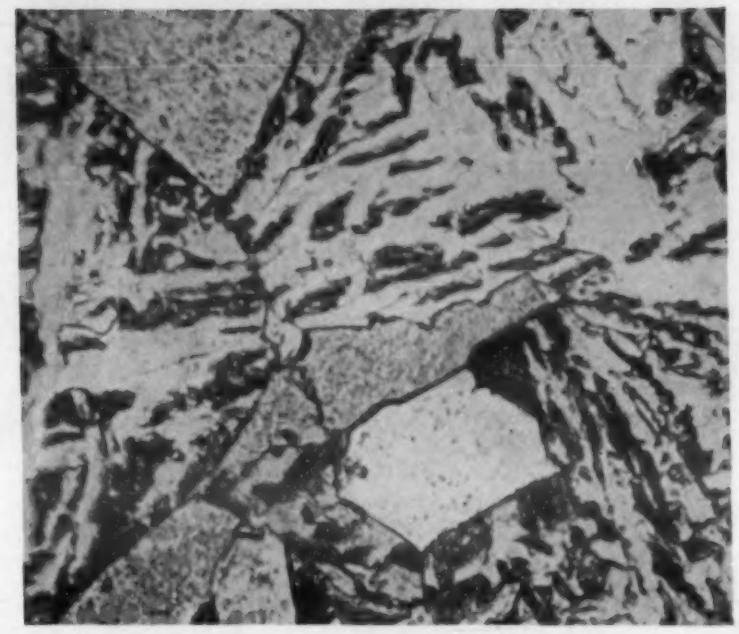
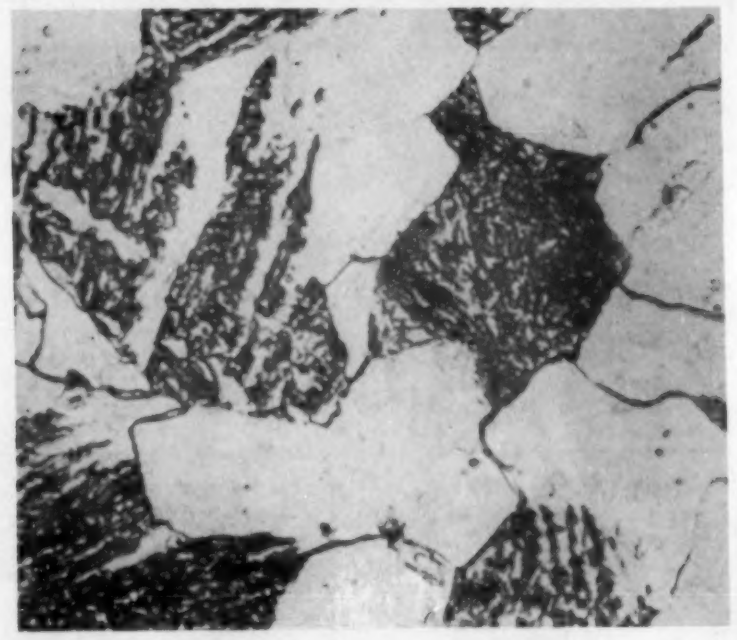


Fig. 8. Structures of the 70,000 tensile carbon steel, 4 in. thick. Top, as received; center, after 16 hrs. at 1,125 deg.; and bottom, after 40 hrs. at 1,125 deg. F. All etched with nital. Each one 1,000X.





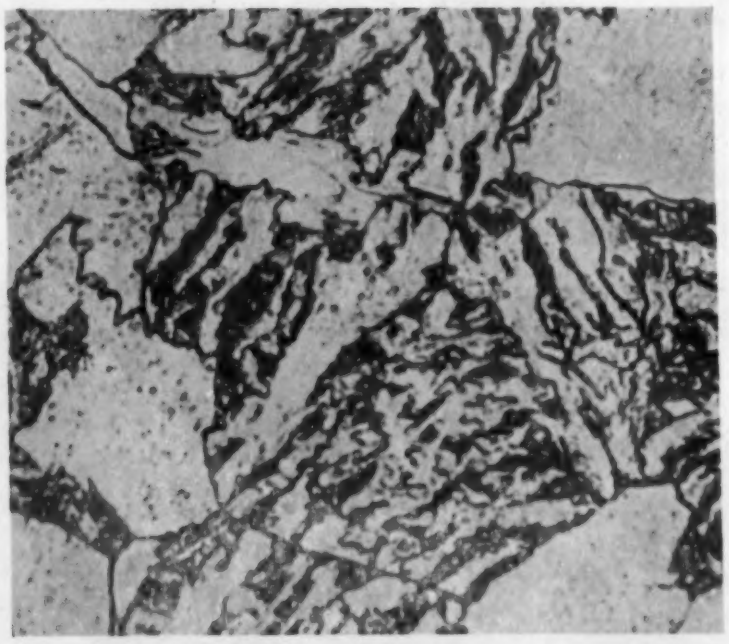


Fig. 9. Structures of C-Mo plate 1 in. thick. Top, as received; center after 6 hrs. at 1,200 deg.; and bottom, after 7 hrs. at 1,200 deg. F. All etched with nital. Each one 1,000X.

Table 2—Specified and Actual Properties of 4 in.-70,000 Tensile Strength Plate

Boiler Code Specifications: A.S.T.M.—A-212-39, A.S.M.E. —S55. "High Tensile Strength Carbon Silicon Steel Plates for Boilers and Other Pressure Vessels."

	Specified Item	*Specified Value*	*Actual Value*
Analysis	Carbon	0.35 max.	0.31
	Manganese	0.90 max.	0.77
	Silicon	0.15-0.30	0.21
	Phosphorus	0.035 max.	0.026
	Sulphur	0.040 max.	0.017
Tensile Properties	Yield Point, lbs. per sq. in.	35-41,000	35,750
	Tensile strength, lbs. per sq. in.	70-82,000	72,400
	Elongation in 2 in., per cent	25 to 21	33

Table 3—Specified and Actual Properties of 1 in.-C-Mo Steel Plate

Boiler Code Specifications: A.S.T.M.—A-204-39, A.S.M.E. —344. "Molybdenum in Steel Plaates for Boilers and Other Pressure Vessels."

	Specified Item	*Specified Value*	*Actual Value*
Analysis	Carbon	0.20 max.	0.21
	Manganese	0.50-0.90	0.83
	Silicon	0.15-0.30	0.28
	Molybdenum	0.40-0.60	0.56
	Phosphorus	0.040 max.	—
	Sulphur	0.035 max.	—
Tensile Properties	Yield Point, lbs. per sq. in.	38,500-45,100	61,440
	Tensile strength, lbs. per sq. in.	70-82,000	86,660
	Elongation in 2 in., per cent	25 to 21	25

Fig. 10. Structures of C-Mo plates 4 in. thick. Top, as received; center, after 16 hrs. at 1,200 deg. spheroidization beginning; bottom, after 36 hrs. at 1,200 deg. F., pearlite greatly spheroidized. All etched with nital. Each one 1,000X.

Fig. 11. Structures of Mn-V plate, 13/16 in. thick. Top, as received; center, after 4 hrs. at 1,200 deg. spheroidization beginning; bottom, after 9 hrs. at 1,200 deg. F., pearlite greatly spheroidized. All etched with nital. Each one 1,000X.

Table 4—Specified and Actual Properties of 4 in.-C-Mo Steel Plate

Boiler Code Specifications: A.S.T.M.—A-204-39, A.S.M.E. —S44 "Molybdenum Steel Plates for Boilers and Other Pressure Vessels."

	Specified Item	*Specified Value*	*Actual Value*
Analysis	Carbon	0.25 max.	0.15
	Manganese	0.50-0.90	0.83
	Silicon	0.15-0.30	0.46
	Molybdenum	0.40-0.60	0.48
	Phosphorus	0.35 max.	0.021
	Sulphur	0.40 max.	0.027
Tensile Properties	Yield Point, lbs. per sq. in.	38,500-45,100	44,000
	Tensile strength, lbs. per sq. in.	70-82,000	76,440
	Elongation in 2 in., per cent	23.5 to 20	34.5

Table 5—Specified and Actual Properties of 13/16 in.-Mn-V Steel Plate

Boiler Code Specifications: A.S.T.M.—A-225-39T. Manganese-Vanadium Steel Plates for Boilers and Other Pressure Vessels."

	Specified Item	*Specified Value*	*Actual Value*
Analysis	Carbon	0.20 max.	0.16
	Manganese	1.45 max.	1.24
	Silicon	0.15-0.30	0.16
	Vanadium	0.08-0.14	0.10
	Phosphorus	0.035 max.	Trace
	Sulphur	0.040 max.	0.022
Tensile Properties	Yield Point, lbs. per sq. in.	41,250-47,850	61,700
	Tensile strength, lbs. per sq. in.	75-87,000	83,800
	Elongation in 2 in., per cent	23 to 20	30

(Editorials continued from page 875)

Music and War Production

We have read with no little interest and some surprise the account of an address recently delivered before the New York Metropolitan Section of the American Society of Mechanical Engineers. We have always been cognizant of the fact that "music hath charms" but we did not realize that it could be a factor in the war effort.

In the address referred to, Professor Harold Burris-Meyer, director of research in sound at Stevens Institute of Technology, revealed the "results of what is claimed to be the first scientific, statistical investigation conducted in this country for the purpose of evaluating the effects of industrial music on employee morale and factory production."

Most people have agreed, said Professor Burris-Meyer, that music in industry is a good thing, but no one had records to show why, where, or how. The professor and an associate invaded a number of factories and war plants in the east to measure if possible the extent to which music may or can influence the production rate.

Although the details of making these tests or measurements are not given, it is quite interesting to learn that the data showed that "in 75 per cent of the investigations, production was higher where music was used than where it was not used," and that "increases in production rates, resulting from the introduction of music, ranged from 1.3 to 11.1 per cent. Further studies indicated that the effect was not a transient one." Surprising also is the statement that many of the groups measured consisted of employees on piece work who already were producing at top speed, that Monday morning absenteeism and early end-of-the-day departures were "phenomenally reduced."

Perhaps some advantage can be taken of this research—anything that will promote war production should be considered. —E.F.C.

Some Censorship Protested

A protest against censorship of the results of scientific research has recently been voiced in the annual report of the Welding Research Committee of the Engineering Foundation. Colonel G. F. Jenks, president of the American Welding Society and chairman of the committee's Industrial Research Division, is quoted as saying:

"The division is beginning to feel the results of restrictions in the publication of information because of Government censorship. It believes that the greatest benefits to war production and to victory in the field will result from a liberal policy through which the results of research will be disseminated immediately to American engineers and scientists."

We subscribe heartily to this protest. Many of the results of research not only in welding but in other metallurgical engineering fields have been and are of great scientific and industrial value. In too many cases much of this work has not been published. While we do not want to advocate passing on vital information to the enemy, we do subscribe to as much publicity as is compatible with the public interest, especially if war production and victory will be furthered thereby. —E.F.C.

METALLURGICAL ENGINEERING shop notes

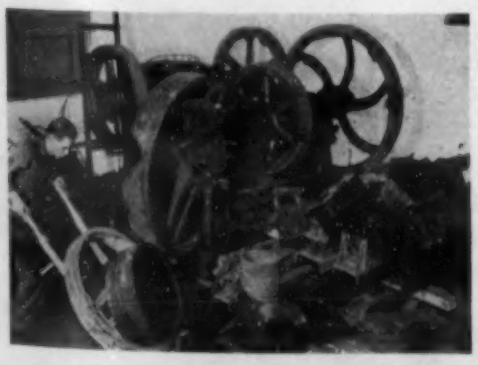
Simple But Practical Salvage Plan

by H. W. Macintosh,
L. O. Koven & Brother, Inc.

Elaborate organizations for efficient salvage are not necessary, nor do outside organizers or consultants need to be called in, at least for comparatively small companies such as ours, we being fabricators of steel and alloy industrial equipment, with plants at Jersey City and Dover.

Each foreman was made a salvage manager in his respective department and was asked to designate what old dies, jigs, fixtures, machines and parts could be spared. reporting to me, the purchasing agent. I instructed the labor department to assign two workers to each departmental salvage manager to clear away the items marked for disposal.

Our scrap is shipped out of the plant three times a week, hence does not clutter up the place and gets into use quickly. Helping inspire us to speedy efficient work is the fact that several of our men are in the armed forces and we don't want to let



them down from lack of weapons. We have periodical meetings to discuss progress and plan improvements. Shipments from our plants in under three months have totaled 750,465 lbs.

With a normal scrap shipment of 80,000 lbs. a month, our shipment from May 20 to July 27 was boosted to 579,770 lbs., or over triple the normal rate. This included 545,550 lbs. of steel, 32,025 lbs. of cast iron, 485 lbs. of brass, 265 lbs. of brass turnings, 965 lbs. of bronze, 280 lbs. of lead and 200 lbs. of rubber.

Old machines have been sold back to industry, being too valuable for scrap. We took out of inventory 190,469 lbs. of rivets, purchased originally for range boiler use, but since "frozen," selling them for their scrap value at a monetary loss but a sentimental gain.

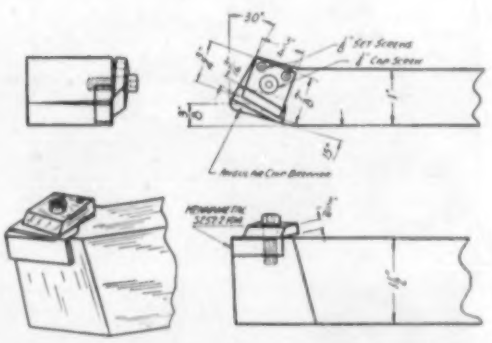
Clamped-On Carbide Tool Tips

Shops making up their own carbide cutting tools can greatly simplify the job and at the same time be assured of strain-free tools by using a clamped-on tool.

A simple design, which has been found very satisfactory, is shown in the accompanying sketch. A tool shank is milled out, care being taken to get as flat a surface under the tip as possible, and a simple clamp attached. The SAE 1045 clamp is not used to break the chips, as it would soon be eroded to destruction. Instead, a conventional chip breaker of angular shelf type is ground into the Kennametal tip.

Any danger of brazing strains is, of course, eliminated entirely, and grinding is greatly simplified since only the Kennametal is in contact with the grinding wheel, no steel to load up and glaze the special silicon carbide grit. One such SAE 1045 shank will serve to mount about four successive tips before it becomes cut and battered badly, and a harder steel would probably last even longer.

As the tip is reground, it is moved forward and out under the clamp, shims



being placed behind it. When the tip becomes too small for service in this tool, it can frequently be brazed into a smaller shank for lighter turning operations or boring.

The freedom from strains due to unequal expansion of tips and shank makes a great difference in tool life, particularly on "home made" tools, which are frequently made under widely varying conditions. In one plant, the use of clamped-on Kennametal tips made it possible to operate for months without a single case of serious tip breakage.

—McKenna Metals Company

Where welding has to be done in semi-inaccessible places, variations of usual technique are often advisable. Thus, welding on the bottom side of a 10 in. water line was facilitated by a mirror placed at an angle on the floor. Moreover, the electrode was bent, though in 99 per cent of applications it should not be.

—"It's Welding Time,"
Lincoln Electric Co.

Identifying "Mixed" White Metals

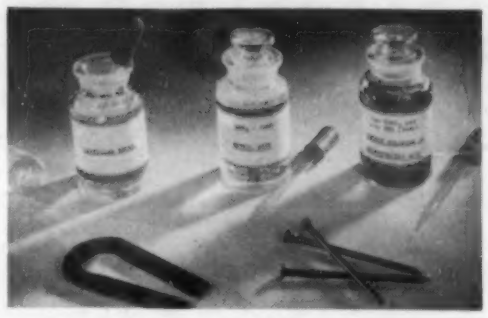
When any of eight familiar white metals get mixed, either in scrap form or in primary form in a warehouse, four simple tests with inexpensive equipment will identify them: Magnet, nitric acid, steel nail and cupric chloride solution.

These tests were listed in an extensive table, with many other tests for several other metals, in the August issue of METALS AND ALLOYS, but herewith we present more details of the manual operations involved.

With the magnet there must be no other steel material nearby. For delicate testing, balance the magnet or specimen on the edge of a bench. If the material is magnetic, a movement of either the magnet or specimen will be observed. Or, the magnet can be suspended on a string.

With the second test, one or two drops of concentrated nitric acid is placed on a cleaned test piece. After a minute or two, there may be a reaction, whereupon the acid should be diluted with three or four drops of water, one drop at a time. If the solution turns either green or blue, the nail test should be used.

A clean iron or steel nail is rubbed in the acid solution on the metal surface,



for the third test, the nail being kept in contact with the specimen. If the alloy contains copper, there will be a deposition of copper, either on the nail or on the metal surface under the acid. Another drop or two of water should be added as the nail is rubbed around to prevent the deposited copper from re-dissolving in the acid.

The fourth test is principally to distinguish Inconel from the 18 per cent chromium-8 per cent nickel type of stainless steel. A drop of cupric chloride in hydrochloric acid is applied to the cleaned metal surface. After two minutes, three or four drops of distilled water is added slowly. The solution is then washed off. If the sample is 18-8 stainless steel, the copper in the solution will deposit on the metal as a copper-colored spot. If the sample is Inconel, there will be no copper deposition, only a white spot appearing.

Chemicals needed for the test are concentrated nitric acid, a solution of 10 grams of cupric chloride in 100 cubic centimeters of concentrated hydrochloric acid.

Tests for Identifying White Metal

Magnetic Test	Nitric Acid Test			Iron Nail Test for Copper	Drop Test with Cupric Chloride in Hydrochloric Acid	Material Probably is
Reaction to Magnet	Reaction to Conc. Aid	Reaction to Diluted Acid	Color of Solution			
Magnetic	Reacts Slowly	Reacts Slowly	Pale Green	No Cu Shows	Not Required	Nickel
Slightly Magnetic	Reacts	Reacts Slowly	Greenish Blue	Cu Shows	Not Required	Monel
Non-Magnetic	Reacts	Reacts	Bluish Green	Cu Shows	Not Required	Nickel-Silver
Magnetic	Reacts Slowly	Reacts	Brown to Black	Not Required	Not Required	Steel or Cast Iron
Non-Magnetic	Reacts Slowly	Reacts	Brown to Black	Not Required	Not Required	"Ni-Resist"
Magnetic	No Reaction	No Reaction	Colorless	Not Required	Not Required	Straight Cr Stainless Steel
Non-Magnetic	No Reaction	No Reaction	Colorless	Not Required	Cu Deposits When Diluted	18-8 Stainless Steel
Non-Magnetic	No Reaction	No Reaction	Colorless	Not Required	No Deposition of Cu Occurs	Inconel

Development & Research Div.,
International Nickel Company.

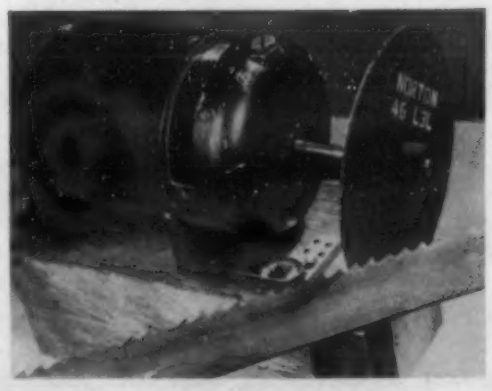
Resharpening Metal-Cutting Saw

by George Coffey
Providence, Rhode Island

Power hack saw blades, when used in cutting up such bar steels as 4140, 3135, Monel metal and stainless steels, get severe punishment, and I have seen as many as six blades discarded from each machine in a day, retailing at $1.00 each.

However, I put them back into use by employing an inexpensive Norton thin black emery wheel, Type 46 L3L. This can be applied to any shop grinding lathe. Or an emery wheel could be used in a pinch if properly shaped up.

I just touch up the back angle section



of the dulled saw blade tooth to establish a new sharp cutting point. I hold this back angle of the tooth against the side of the emery wheel near the wheel's edge. Each blade can be re-conditioned in from 3 to 5 minutes.

Usually the blades can be reground about six times, meaning that $6.00 worth of saw blades are being bought for $1.00. Further regrinding is limited by the "set" disappearing. The "set" is that feature where alternate teeth are bent outward to provide clearance for the body of the blade.

Metallurgical Engineering Digest

FERROUS AND NON-FERROUS

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CONTENTS

Film-Impact Continuous Casting 912
Backing-Up Rolls 914
Aluminum Casting Alloys 918
Light Steel Castings 920
Making Ferro Alloys in Brazil 922
Control of Multi-Fuel Furnaces 922
Dry Blast Production 924
Ford Makes Magnesium 926

Film-Impact Continuous Casting

Condensed from "Steel"

Thin films of controlled thickness are formed continuously and instantaneously from a molten metal stream from a ladle by a moving, clean, and dry metallic section such as a rotary disk, a metallic belt, or circular rim of a drum. Material, thickness, thermal conductivity, and surface condition of this moving metal section are selected to produce the fastest possible heat removal from the molten metal film. Heat is transferred to the air by radiation or to a liquid coolant. Molten metal film adheres to and is carried by the moving section and when it becomes supercooled, it loses its adhesion to the moving section.

As it becomes free, the propelled metal film is directed continuously to impact into a mold under its high velocity. For certain molds, such as sand molds, this high velocity is reduced by reshaping the film to form a supercooled stream before it reaches the mold. By adding a small surfacing roll acting at the point where the molten metal reaches the supercooled state, films formed over the rim of a rotating drum can be collected as solid continuous strips.

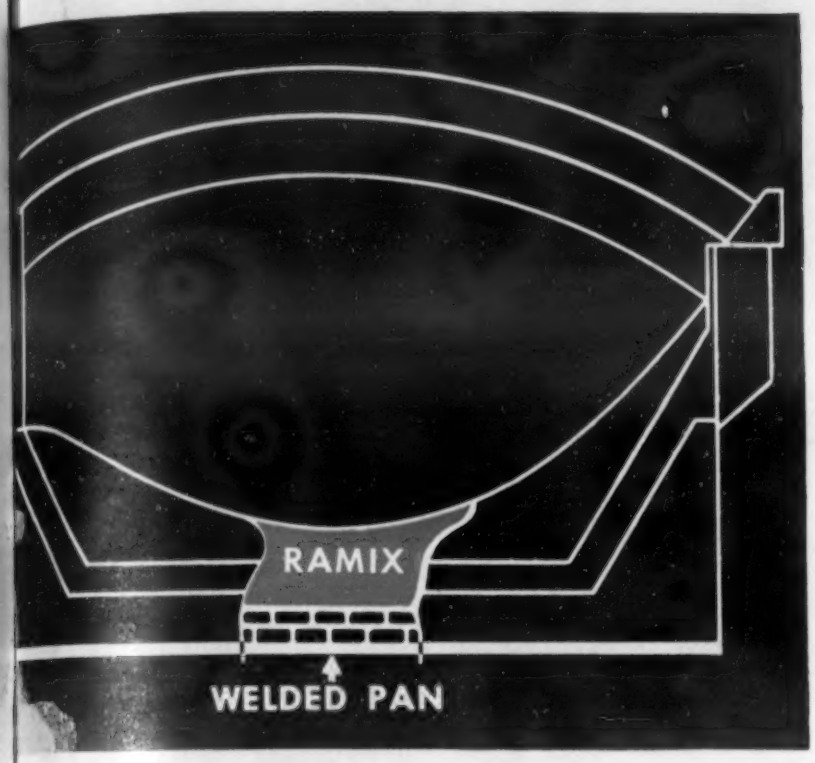
Such strips, 0.004-0.040 in. thick, have been obtained at 500 to 3000 ft. per min. with various metals, including lead and alloy steel. This process can be used for producing most metal products in sand, metal, and continuous molds and for metal dies. Extremely rapid heat removal from molten metal film prevents segregation and liberates all contained gases before the supercooled film reaches the mold. The products have a crystal structure, density, and physical properties comparing favorably with those of forged and rolled products of the same composition.

Impact-casting machinery is basically an apparatus for large and continuous operation, designed to handle from a few lbs. to 3 tons of molten metal per minute. It is essentially a heat transfer and propelling unit. Ingots of all metals can be cast. These ingots have a uniform structure throughout and are free from defects. The process can be used to produce commercial products directly to finished sizes and shapes or ready to be finished by cold rolling or drawing.

The equipment required comprises an impact-casting machine directing film of supercooled metal into a short mold, generally water cooled. Metal film is continuously impacted to a billet, plate, strip, rod, rail, tube, wire, etc., as desired. A stand of rolls running at a synchronized speed continuously pulls the solid product out of the forming mold giving it a reduction pass if desired. Accessory equipment is also synchronized with the foregoing.

The function of the mold is similar to a forging or extrusion die as it only shapes the plastic product while the latter travels to pinch rolls. For sand castings, conveyor or turntable equipment is required to carry and index the successive molds under the impact-casting machine. No risers are needed. Castings produced in metal dies or permanent molds require a fast mechanical operation such as used

"How quickly can you repair a bottom that a heat's gone through?"



How Ramix was used to make a permanent repair of a large hole cut in an open hearth bottom when a heat went through.

Ramix is a scientifically prepared magnesite refractory, shipped in bags, ready for quick installation. It needs only to be tempered with water before ramming.

● **The first time that question was posed to a Basic Refractories Field Engineer was two years ago, when Ramix was just earning its reputation as a dependable cold-ramming refractory for permanent repair of open hearth bottoms.**

There was no hesitation in the Basic Engineer's answer: "In a very few hours after you get the pan welded." And the job was actually completed—pan welded, Ramix tamped in, bottom dressed and the furnace ready to charge—in less than 24 hours after the break through.

Here's the simple procedure, followed in this and several other break-through cases since then: As soon as the furnace was cool enough, new plate was welded solidly to the pan from below. Next, Ramix tempered with water was shoveled into the hole (approximately 6 x 3 feet) and tamped in to conform to the old bottom contour.

Then, after the furnace was brought back up to temperature, banks and bottom were washed down and the entire hearth dressed lightly with magnesite. The furnace was then ready to resume operation, with a *permanent* bottom repair that has stood up under hundreds of heats since then.

Basic Engineers are "standing by" for all steel plants nowadays. They are *your* refractories service men and are always glad to assist. Don't hesitate to call upon them for help.

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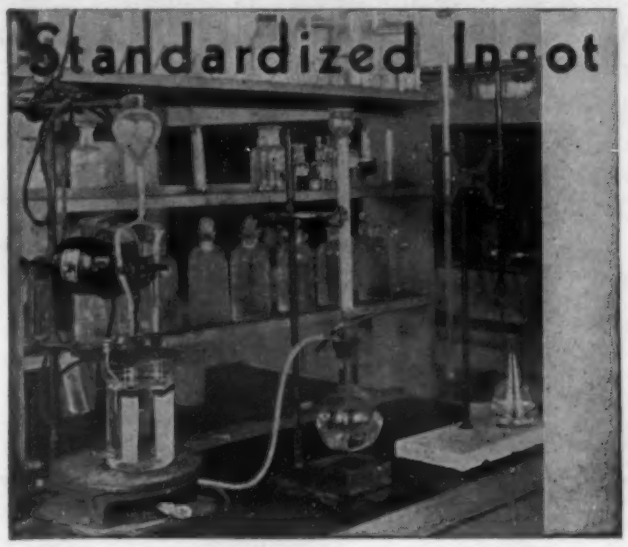

A copper-silicon-zinc alloy of the useful and versatile "Tombasil" family has been developed expressly for the war trend in nonferrous castings.

Its use releases relatively large quantities of tin used in bronze alloys formerly required for such castings.

According to exhaustive laboratory and field reports, this new alloy, known as Ajax "Navy" Tombasil, possesses physical properties far in excess of either Govt. "G" Bronze (88-10-2 and 88-8-4), Spec. 46M6G; or "M" Metal, Spec. 46B8G; as well as the Cu. Si. Alloy known as Spec. 46B28.

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in die-casting machines for closing and opening the molds and ejecting the castings. Such castings require less machining than forgings and can be produced at a rate many times faster than the fastest forging equipment now in use.

The most efficient use of the film-impact process requires a continuous supply of molten metal. Two of the largest steel manufacturers in Brazil are installing equipment for operating under this process.

The method can be used for producing and refining steel. In this case, molten iron, high enough in silicon, is run through a film refining machine, which forms the iron into a thin continuous film in intimate contact with a film of molten slag (separately fused iron ore, or iron oxide with lime and flux) and insures complete diffusion by forcing the lighter molten slag through the molten iron. This reduces and removes some phosphorus, all the silicon and manganese, and some or all the carbon of the pig iron under the controlled operating temperatures. Machines can be designed to handle 1 to 3 tons per min.

Partially refined metal is fed immediately into a second similar machine which forms it into a thin film in intimate contact with another film of molten slag of the proper composition (calcium or other slag) which removes the remaining sulphur and phosphorus. Refined metal is separated centrifugally from the used slag. The refined steel is so clean it can be run directly into an impact-casting machine or into a ladle. Refining operation is very rapid because of the tremendous surfaces of reaction created under the process. Reactions are almost instantaneous and being mostly exothermic no fuel is needed during the operation. The yield of steel is greater than the weight of pig iron used, due to incorporation of iron from molten ore used in this reduction.

—J. M. Merle, *Steel*, Vol. 110, June 22, 1942, pages 82, 84, 102-103.

Backing-Up Rolls

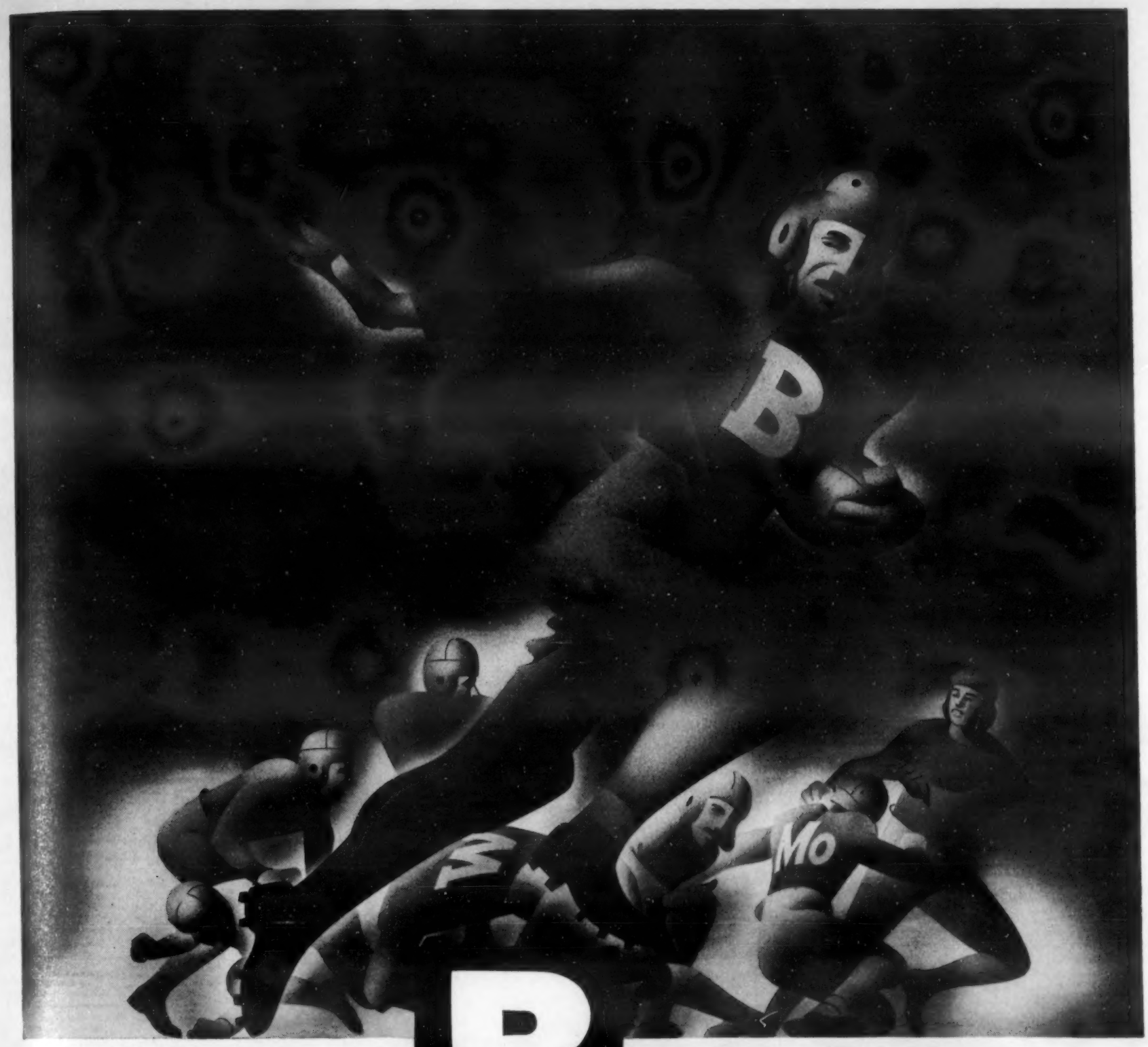
Condensed from "Iron and Steel Engineer"

A roll sleeve, while in service, is subjected to many variable stresses, some in the form of static pressure and some in the form of impact. Forged steel, for reasons which are well known, possesses greater density and greater homogeneity than the average casting and this quality in the forged sleeve is one of the reasons for expecting greater life than the expected life of a solid cast roll, or a cast roll sleeve.

The second reason, which is of great importance, is the comparative ease and safety with which a sleeve may be hardened and tempered, as compared with the manufacture and hardening of a solid roll, due to mass involved.

Making the Rolls

Since relatively large ingots of the highest quality are required to be used for sleeves, electric or acid open hearth steel is recommended. The most popular method



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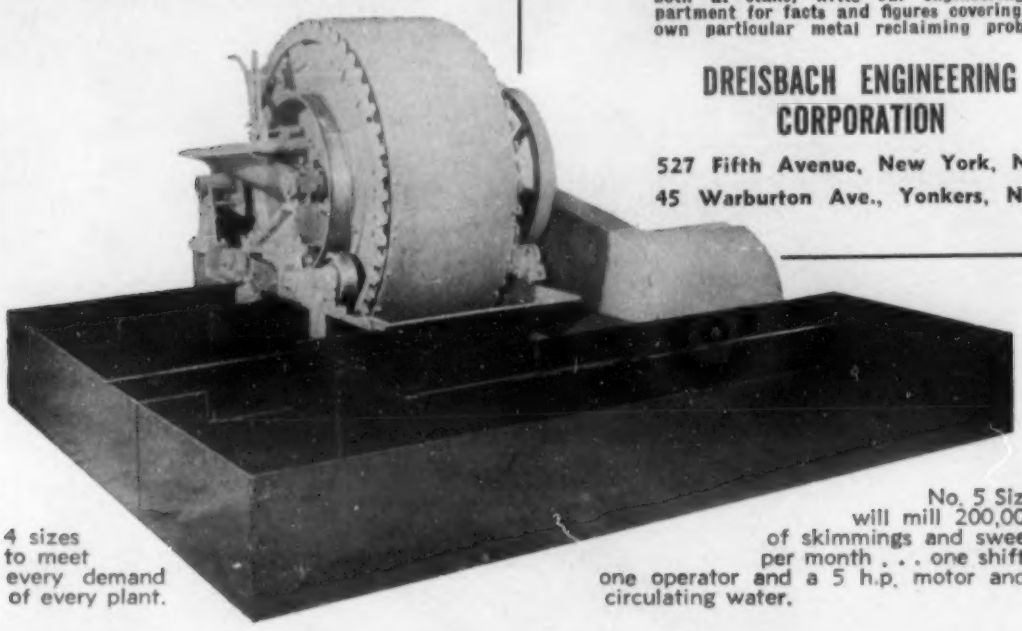

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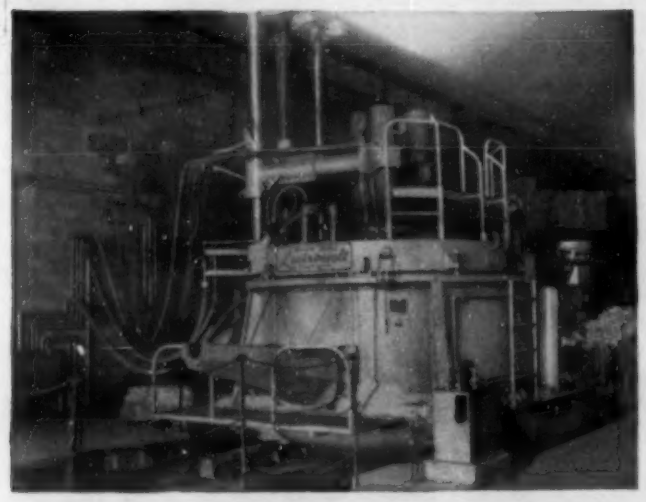

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used is to cog the ingot into a billet and then cut off the required weight, upset forge, hot punch and mandrel forge. After forging, cooling at a predetermined rate must follow in order to avoid flakes and internal fractures.

After forging the sleeve on a mandrel, which permits thorough reduction and grain refinement throughout the entire cross-section of the forging, the sleeve is given a high normalizing treatment, followed by an annealing treatment. After rough turning, the sleeve is hardened and tempered to the required hardness.

The superiority of this type of treatment for backing-up roll sleeves is due to the hardness which may be obtained, as well as the fact that hard cementite particles are distributed uniformly throughout the steel and contribute to better wear resistance.

The selection of the proper hardness of a roll sleeve is very important. High hardness minimizes spalling, but materially increases failure by splitting. Too soft a sleeve will promote spalling and also develops an "out of round" condition and loosens on the mandrel.

The hardness generally falls between 55 and 65 scleroscope for the average. Hot mill backing-up roll sleeves are made to the low side of hardness and cold mill sleeves to the high side because the cold mill pressures are higher than that of the hot mill.

Arbors are either turned down from solid rolls, or made from forgings. If made from forgings, they are usually of a mild alloy steel, air-hardened and tempered to secure a combination of hardness and toughness desired to withstand the extremely high pressure developed in a mill.

After final heat treatment, the arbors are machined and the body ground to a pre-determined size for the shrinking of the sleeve. The hardness of a forged and heat treated arbor will vary according to size, but generally speaking, the average is between 35 and 45 Shore hardness.

The major portion of the arbors used are made from worn-out or badly spalled cast steel solid rolls. These cast steel arbors are apparently entirely satisfactory as some arbors are re-sleeved three and four times before being scrapped.

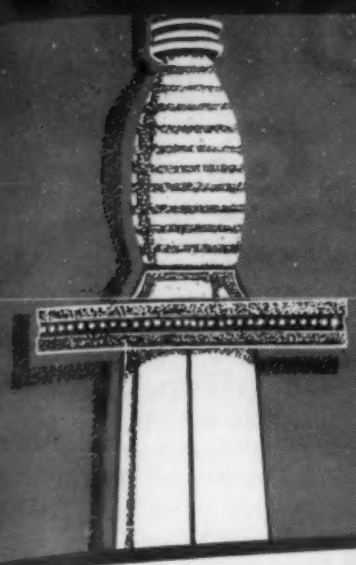
Sleeves are now designed with a shoulder on the arbor and a recess on the inside diameter of the sleeve. A lock ring is also inserted either at the shoulder end or the opposite end of the sleeve. This device will prevent the sleeve from moving laterally, but the shrinkage is all that prevents the sleeve from moving circumferentially.

It is advisable, particularly in the case of long sleeves, to permit cooling during shrinkage of the central portion before cooling the ends. If the reverse process occurs, improper bearing at the center will result and the inherent stresses, in addition to the working stresses, might cause cracking of the sleeve.

Service Factors

There are many factors which affect the life and service of roll sleeves. At the extreme high pressure developed in the mills, all sleeves are subject to cold working of the surface metal. In due course of time, this metal will fatigue and develop small

Does this SWORD OF DAMOCLES *Menace Your Floors* (AND YOUR PRODUCTION?)



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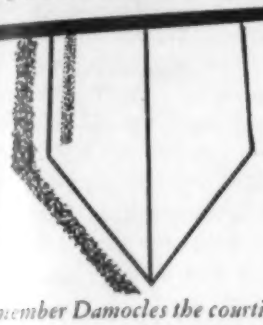
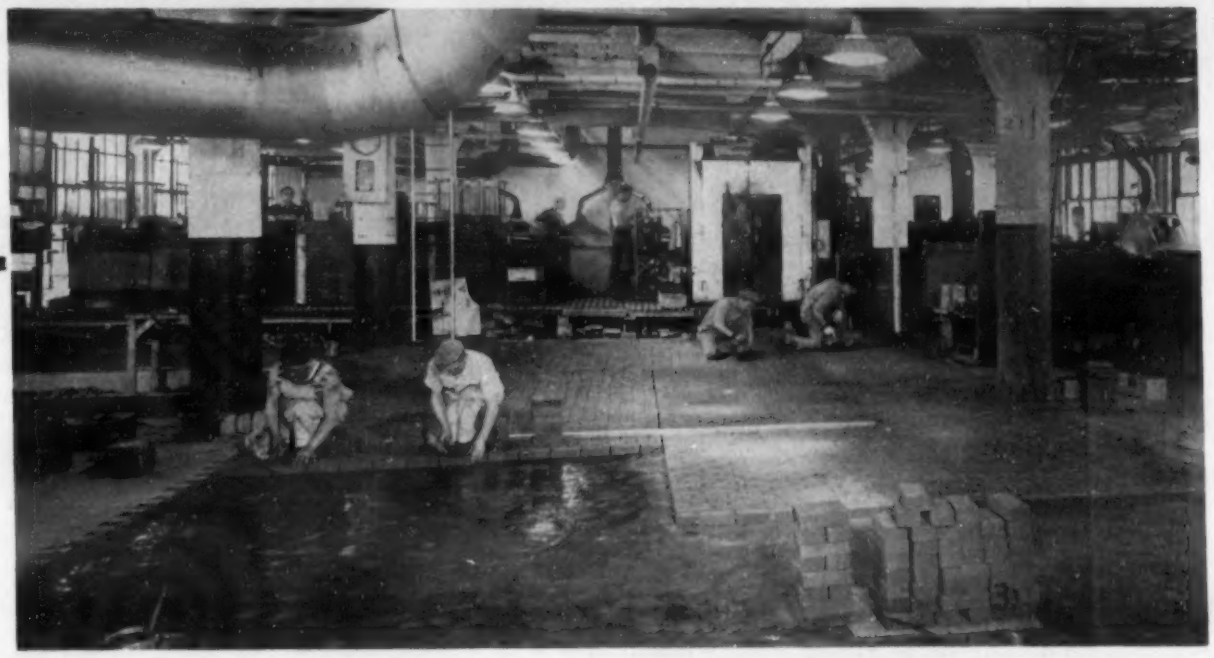


• *You remember Damocles the courtier, seated by order of the tyrant, Dionysius at a banquet with a sword suspended over his head by a single hair.* . . . . . .



The floor pictured at the right, built of ATLAS Acid-proof Cements and ATLAS Acid-proof Brick, thrives on acids, alkalis, corrosive salts, organic and cleaning solvents . . . and takes the toughest sort of mechanical punishment in its stride.

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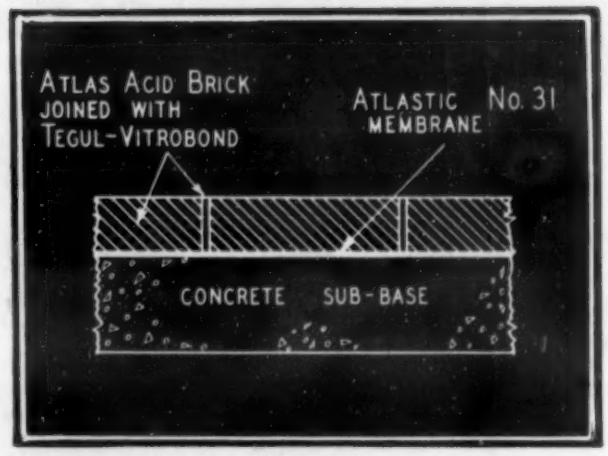

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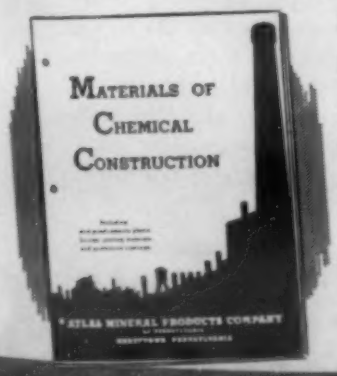

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cracks. If the cracks are permitted to grow, large spalls are certain to result.

However, if these cracks are removed by frequent light cuts, in the lathe, the life of the sleeve can be materially improved. It is generally accepted that cracks cannot be ground out, but will increase in depth and remain in the roll after the grinding operation.

The service of a roll or sleeve is generally referred to as so much tonnage rolled and no reference made as to which stand the backing-up roll had spent most of its existence. The author's company has advocated for years that the service of strip mill rolls and sleeves should be discussed in relation to footage or mileage actually going through the rolls, rather than tonnage.

The true service life of a roll or rolls sleeve cannot be determined by the actual tonnage produced, for the stand of the mill in which the roll was used must be taken into consideration. The only equitable method of comparing the service received would seem to be to establish a factor to be used in converting the tonnage rolled in each stand to terms of some one stand of the mill.

This should be done on the basis of relative footage of roll circumference per ton of steel produced. For the want of a more accurate term, we shall call this figure "foot-tons." This comparison is not entirely correct since the thickness of the piece in each stand is not considered, nor is the variable percentage of reduction in each stand compensated. But it is much more nearly a measure of merit than the bare statement of final tonnage.

Examples of the establishing of such factors and their application to service records are given.

—J. A. Succop, *Iron & Steel Engr.* Vol. 19, Sept. 1942, pp. 42-47.

Aluminum Casting Alloys

Condensed from "ASTM Bulletin"

Most commercial metals contain metallic and non-metallic elements which are generally classified as "impurities." The purest commercial aluminum still contains a total of about 0.2 or 0.3 per cent of such elements. Where aluminum is combined with other metals to form alloys, there are 14 common elements which may be desired alloying elements, innocuous or harmful.

Aluminum can be purified electrolytically, but the cost is too great to make it commercially practical. Since these minor alloying elements cannot be removed, it becomes necessary to use these alloys to the best advantage, especially under the present shortage of aluminum.

Remelted aluminum has been successfully used for a long time, but is limited by existing specifications. These were drawn in this limiting fashion because complete information on the effect of these elements was not generally known and before the war there was plenty of pure aluminum.

The problem now is to determine the following questions:

1. What is an "impurity," and when is a minor alloying element an impurity?
2. What effect has this "impurity" on the physical properties?
3. What are the usable limits of this "impurity"?

This discussion is limited to aluminum casting alloys which are sand cast, chill cast or die cast, and only the casting alloys specified by the ASTM will be considered. Two main groups of alloys are distinguished: the aluminum-copper alloys and their derivatives, and the silicon alloys and their variations.

To discuss the limits of impurities or minor alloying elements one must consider the influence of these elements (1) in respect to physical properties and (2) in respect to corrosion properties.

Important Properties

The first is easy to analyze and the second hard to prove or disprove. However the problem of corrosion is not as important as the physical properties, which can be accurately measured and which give numerical data directly usable for designing of castings, machines, and apparatus. It is important to be well informed regarding the effect of these minor alloying elements on the castability, machinability, tensile strength, yield strength, proportional limit, elongation, impact strength, heat treatability, and stability at elevated, subnormal and room temperatures.

Castability is listed first because a poor casting, made of a high-strength, difficult-to-cast alloy, is less desirable than a sound casting made from a less strong but easy-to-cast alloy.

Machinability is next. Machining cost is high; tool life is low; it might not be possible to obtain a finish which will guarantee good bearing; or, in stressed members, drag marks of the tools will cause notch effects which may lead to weakness of the casting.

It has been shown that, with certain exceptions, the effect of the minor alloying elements on the mechanical properties of aluminum copper, aluminum-copper-silicon, and aluminum-copper-nickel alloys is either beneficial or innocuous. The only element which requires rigid control is magnesium. In all these alloys (with the exception of the 10 per cent Cu and the Y-alloy) 0.10 per cent Mg is the maximum which can be tolerated without causing loss in ductility. In cases where ductility is of prime importance, limitation of magnesium to 0.05 per cent is indicated.

Effect of Specific Elements

Iron is the next element which must be watched carefully. Since much of the contamination arises through the foundry process, every precaution should be taken to prevent unnecessary iron pickup. This is the more serious as the silicon content increases.

All the other elements such as manganese, titanium, nickel, chromium, and cobalt in one group; and tin, lead, antimony, bismuth and cadmium in another group, are usually present in small enough amounts so that there is no harm; in fact in many cases great advantages occur when they are present. Furthermore, with good laboratory control and proper technique, these elements can be balanced so that the maximum benefit is gained by their presence.

The presence of these elements sometimes changes the casting characteristics and some adjustments in the foundry practice may have to be made to suit the alloy.

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In many cases, the alloys have a somewhat lower melting point and greater fluidity; therefore, the pouring temperatures can be lowered.

In most specifications only a minimum tensile strength and elongation are given which would imply that these two are the only properties which the engineer requires. In many alloys the elongation seems to be of prime importance. Remelt alloys usually exhibit the greater proportional limit and yield strength and somewhat lower elongation. It therefore seems advisable to supply the designing engineers with data on proportional limit and yield strength in addition to the present information on tensile strength and elongation. If these data were made available for aluminum alloys, the question of composition would be simplified.

"Remelt Alloys"

The statement is often made that remelt alloys contain more oxides than so-called high-purity alloys. However, there is sound reasoning which can disprove it. Fluxing, skimming, and holding the metal are identical procedures in the production of virgin and remelt metal, and there is no basis for the assumption that these methods work any differently on virgin aluminum than on remelt aluminum.

It is, of course, possible to remelt aluminum and not remove the excess of nonmetallics properly. This is most likely the reason why nonmetallic impurities and remelt metal have become so closely associated in the minds of many.

"Remelted" aluminum has been in competition with primary metal for many years, and when the composition of the remelted aluminum is comparable with that of primary, no difference in properties is found. That should be conclusive, both on the question of oxides and on any other prejudicial opinions regarding remelt aluminum.

—W. Bonsack, *ASTM Bulletin*, Aug. 1942, pages 45-54.

Light Steel Castings

Condensed from "Foundry Trade Journal"

The routine employed to produce liquid steel at the periods when it is most required in a light castings foundry is discussed. Two processes are used, the basic electric and the Tropenas converter. Emphasis is laid on standardized charging and working in the electric furnace, and a special technique employed in the cupola supplying iron for the converter. It is claimed that, by the employment of these methods, loss of production caused by the pouring floor waiting for the furnace, or vice versa, is eliminated.

The chemical changes that take place during the 2-hr. period of melting in the electric furnace probably occur in three phases: 1. Elimination of silicon and manganese. 2. Elimination of phosphorus. 3. Elimination of carbon.

In Tropenas converter practice (20 cwt. Tropenas converter with a positive Rootes blower), a balanced blast cupola, 27 in. dia., capable of melting 3 tons of iron per hr., and one 2-ton capacity ladle for receiving the cupola iron for transfer to the converter were used.

A normal blow in the converter is as follows: As the blast strikes the bath, light yellow sparks and a small flame proceed from the mouth of the converter. In about 5 min. a reddish brown flame appears directly over the tuyeres. This spreads and develops in length and marks the beginning of the ignition period. At this stage any ferrosilicon that may be considered necessary is added in lumps. Three minutes after ignition, the flame attains its full height, and a vigorous boil ejects a little slag and metal from the mouth of the vessel. At this point the blast pressure is gently reduced to 3 lbs. per sq. in. After the converter is turned down, deoxidation takes place by addition of 45 per cent ferrosilicon and 80 per cent ferromanganese. The carbon is adjusted by the use of cupola melt. The tapping temperature of converter metal compares favorably with electric furnace metal.

It is usually held that converter steel is more fluid than basic electric steel. In the experience of the authors, temperature is by far the strongest factor in fluidity. Temperature readings over a considerable period have shown that converter steel is consistently 104 to 140 deg. F. hotter than electric. It is their opinion that with well-made steels the difference in fluidity of the two types of steel at the same temperature is very small.

—C. H. Kain and L. W. Sanders, *Foundry Trade J.*, Vol. 67, July 23, 1942, pages 281-286, 292.

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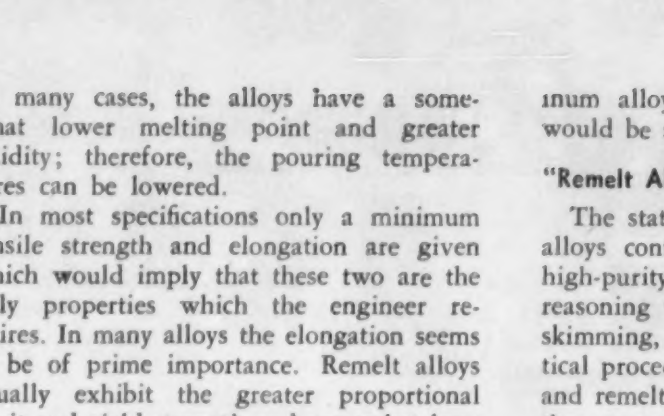

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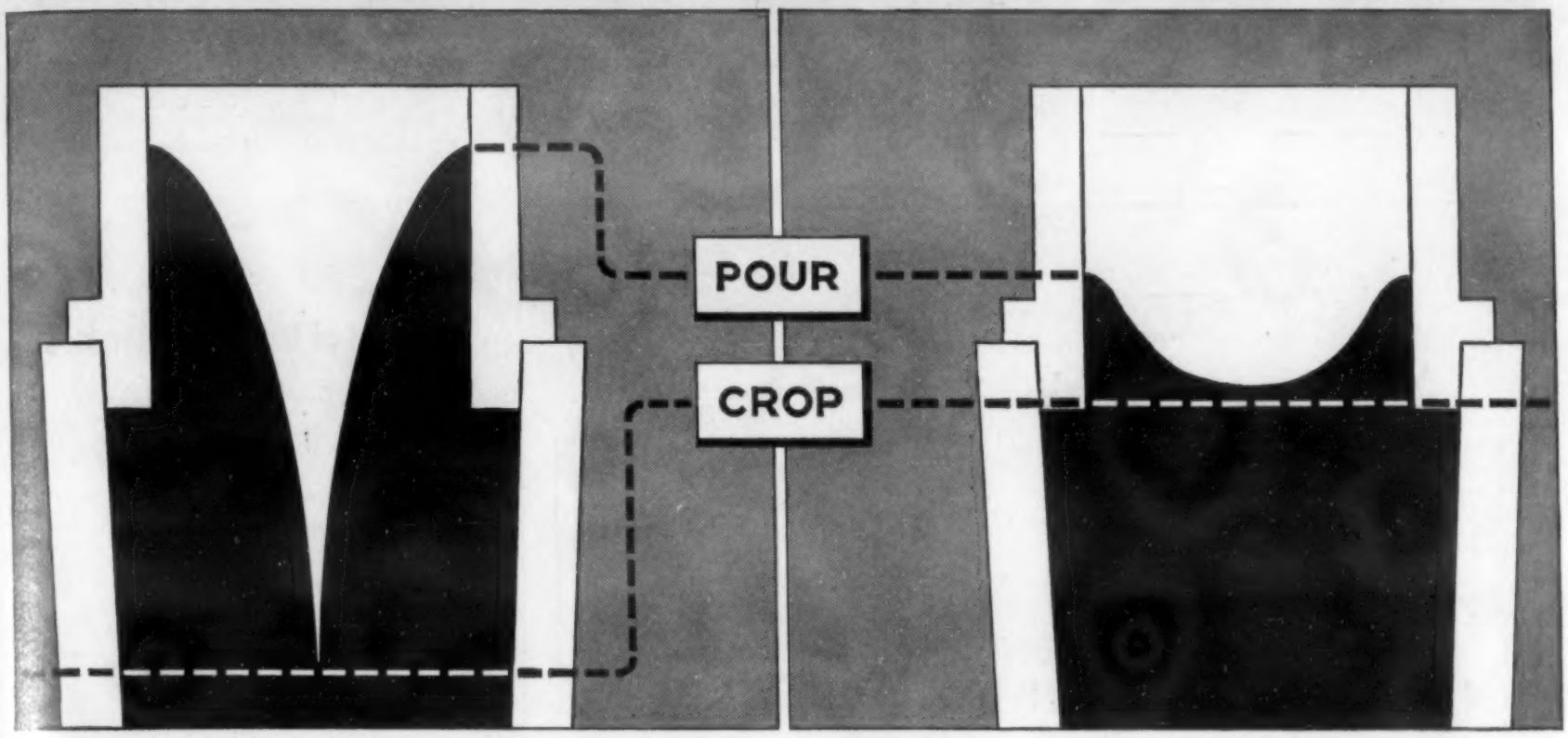

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Other advantages of Armstrong's Ingot Insulation are, (1) *Repouring possibility:* When it is necessary to use more than one ladle of molten metal to complete an ingot, Armstrong's material keeps the metal in the top of the mold molten long enough so that more metal can be added to the ingot without entrapping undesirable elements. (2) *No chemical change:* Armstrong's Ingot Insulation contains no elements in sufficient quantity to influence the chemical composition of the ingot.

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Making Ferro Alloys in Brazil

Condensed from Proceedings of the Electrochemical Society

Early in 1941, owing to big opportunities which seemed to be available in South America and in view of the desire on the part of the Federal Government to develop closer relations with the South American Republics, a study was made of economic, industrial and social conditions in Brazil, with the view of developing certain natural resources in Brazil.

The manufacture of steel, which will soon be a basic commodity in Brazil, requires auxiliary materials. The ferro alloy group is one of the most important of these.

A preliminary survey of raw materials indicates that the basic materials necessary for electric furnace production of ferromanganese, ferrosilicon, ferrochrome, and ferrotungsten are available near the suggested site of the plant. Labor rates are very low, and electric power from the Paraúna Falls plant is now being sold at about 0.4 cents per kw.-hr., in small quantities. Large blocks bring a lower rate.

The suggested initial installation would represent an investment of $650,000, and would produce ferromanganese, ferrochrome, and ferrotungsten having a yearly value of $1,500,000. The estimated gross spread between selling price and operating cost is $636,000. The operating costs include labor, materials, power, and all expenditures, but do not include taxes, reserves, depreciation, and similar items.

The suggested completed plant is to have increased capacity for ferrochrome and ferrotungsten and in addition is to have furnaces for production of ferrosilicon, calcium carbide, silicon carbide, and electric cast iron. For the entire plant the estimated total investment is $2,064,000 and the yearly estimated spread between selling price and operating cost is $1,569,000. Again, the estimated operating costs do not include interest, depreciation, taxes, and similar capital charges.

Operation of the proposed electric furnace plant would not involve serious competition to American manufacturers.

—W. A. Darrah, *Proc. Electrochem. Soc.*, Preprint 81-29, April 1942.

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Control of Multi-Fuel Furnaces

Condensed from "Iron and Steel Engineer"

The use of more than one fuel on open hearth, soaking pit furnaces and boilers has stimulated the development of automatic control equipment for these applications. The earlier applications of control to furnaces fired in this manner were usually accomplished by equipping the air fans with more than one inlet. With this arrangement it is possible to control combustion air in relation to each fuel being burned by regulating a damper at the inlet of the fan.

A later development in control equipment provided a means of summarizing the various fuel flows so that an index of total air requirement would be secured. From this index combustion air could easily be controlled.

The use of multi-fuels not only aids in better fuel distribution throughout the plant, but also permits greater flexibility in operation to control flame character.

Features Desired

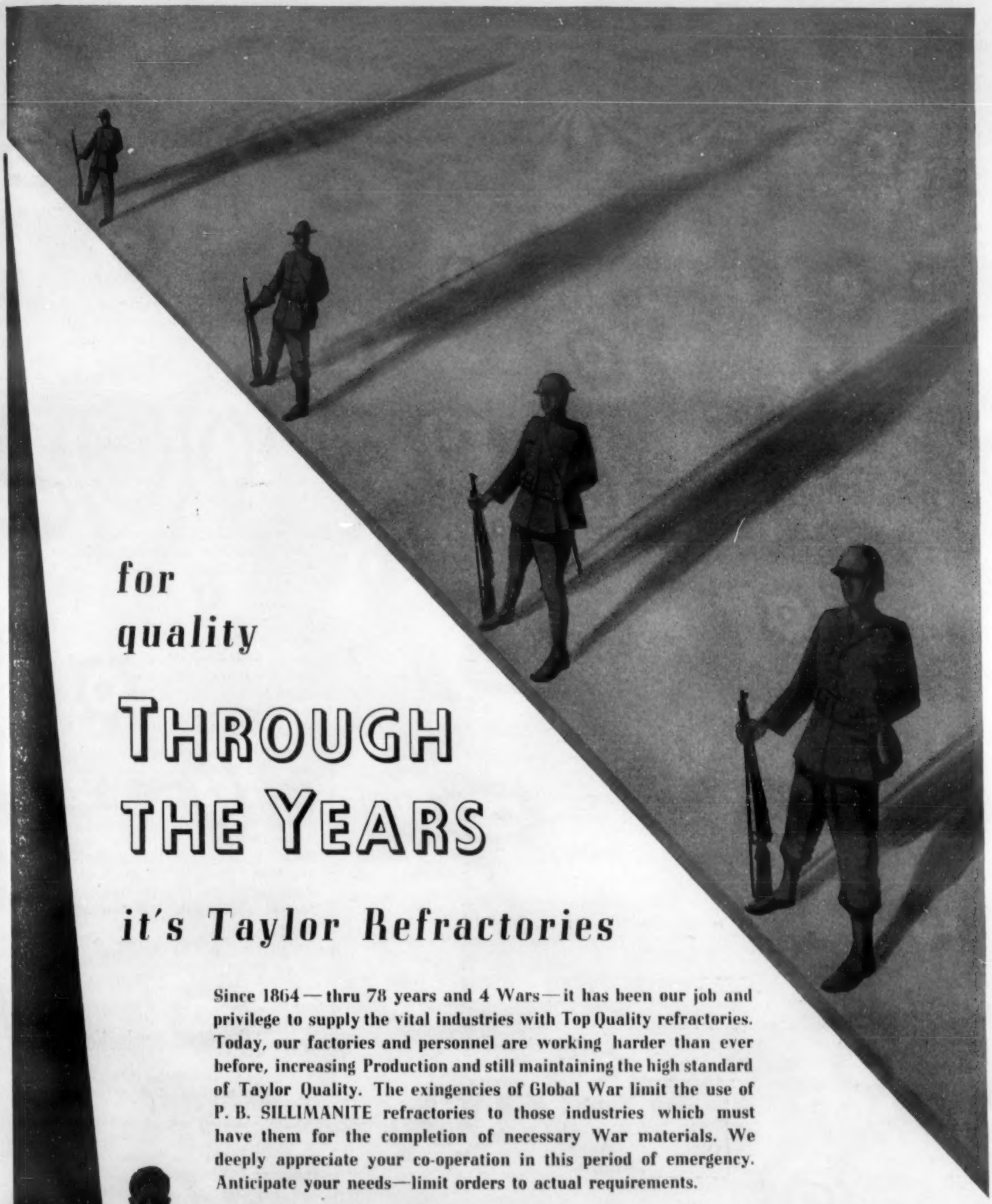
The desired features of any summarizing device are as follows:

1. Compensate for air infiltration.
2. Use any flow impulse characteristic.
3. Adjust for various atmospheres.

As most flow indications follow a square root law, that is, the differential pressure varies as the square of the flow, the corresponding relationship between the two is parabolic. This makes it impossible to add differential pressures representing individual fuel flows, to obtain an indication of the total air requirement. Therefore, any method which is employed to proportion combustion air to more than one fuel flow, requires that this relationship be taken into consideration.

One method which has been used to summarize fuel flows is to extract the square root cut of the flow indication. Then by totalizing these values an indication of total fuel measurement is secured.

Another method, which has been in use



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for a number of years, is to make use of pilot flows proportional to the respective fuel flows and to summarize these pilot flows, thus securing an index of total air requirement. Many variations of this summarizing principle have been employed in open hearth and soaking pit practice to secure the desired operation peculiar to any plant condition. The equipment described in the following supplements the summarizing equipment described previously and provides for the features stated in the basic problem.

Operating Principles

The first portion of equipment required to accomplish the above is done by means of a "transformer," which converts or transforms the flow impulses into proportional cylinder movement. The differential pressure developed by an orifice in the fuel line acts upon a diaphragm system, so that the jet pipe controls through the hydraulically operated cylinder an adjustable cam in such a way as to balance the force of the diaphragm by compressing the opposing spring.

Thus there is a definite relation between fuel flow and the cam movement. The adjustment then made is such that the movement represents "air demand" for a given fuel flow. Having thus obtained a movement, which is directly proportional to the air requirement for the fuel which is being used, the next step is to summarize this indication with one obtained from other fuel or fuels. The cam used on this regulator has an adjustable pitch, which permits compensation for any characteristics of the fuel impulse.

After establishing a mechanical movement, which is directly proportional to the air requirement for one fuel, it is merely necessary to take the same step for the second fuel and add the mechanical movements of both. Thus we establish the air requirement for the two fuels.

The summarization of the two mechanical movements is accomplished by means of a summarizing gear. This device has the ability to add or subtract mechanically two mechanical movements so that the result is always the correct sum of the two.

In principle it is similar to that which is employed in the differential gear of an automobile, in which the drive shaft will remain at the constant speed, while one rear wheel is turning faster than the other while making a turn. The summarizing gear is merely the reverse operation of the differential on a car in which the two shafts are moved in relation to the air requirement and the summation of these two movements is summarized by the summarizing gear.

Assume a typical example where two fuels are being burned and the orifice plate located in the line of fuel No. 1 develops a differential pressure proportional to the fuel flow. This differential in turn actuates through the regulator and its adjustable cam and cylinder a mechanical movement proportional to the fuel flow so as to set up the actual air requirement.

This mechanical movement is directly connected to one-half of the summarizing gear. For the second fuel a similar arrangement is provided and its mechanical movement, proportional to the fuel flow and setting up its air requirement, is connected to the second half of the summarizing gear. Examples are given of total airflow control and of heat-input control with manual, semi-manual and automatic control features.

—J. C. Vaaler, *Iron & Steel Engr.*, Vol. 19, Sept. 1942, pp. 134-140.

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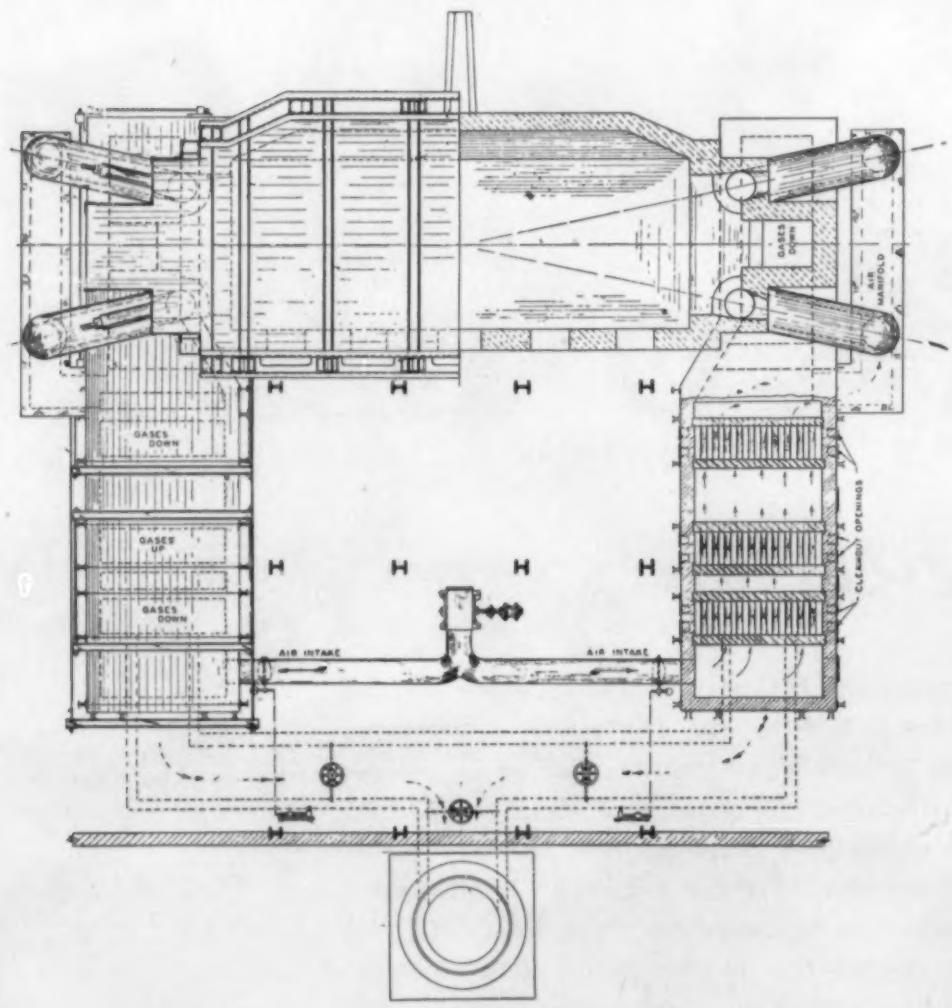

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Dry Blast Production

Condensed from "Canadian Metals & Met. Industries"

Four methods of increasing pig iron production are: (1) The use of higher grade ore; (2) the construction of new furnaces; (3) oxygen enrichment of blast; and (4) the use of dry blast.

Any moisture in the air supplied to the blast furnace means additional dilution of the oxygen in the air involving some additional load on the blowers, when they are already handicapped by having to blow air at the higher temperatures of the summer season. At the temperature of molten iron, water vapor reacts rapidly with coke in an endothermic reaction, thereby additional fuel is needed to maintain the heat. This may amount

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to as much as 10 per cent of the total fuel, increasing by an equal amount the total volume of air to be compressed for any given temperature, and causing more coke ash to be smelted.

With full dry blast operation at the Isabella furnaces of the Carnegie Steel Co. at Etna, Pa. 10 per cent increase in production with 10 per cent decrease in coke was obtained. The use of blast of uniform moisture content (about 3 grains per cu. ft.) made possible in one plant an increase of 20 per cent in tonnage and a decrease of about 13 per cent in coke consumption over a 1-yr. period. Minimum benefits should be 10 per cent in output and 5 per cent decrease in coke consumption. Although the average atmospheric moisture is lower in summer, it is not uniformly low so there is little difference in efficiency in winter and summer. A uniform atmosphere is essential for maximum benefits of the use of dry blast.

The three basic methods of removing moisture from the air are: (a) Chemical absorption (b) refrigeration, and (c) adsorption with solids. Solutions of calcium chloride, calcium bromide, lithium chloride and lithium bromide have been used as chemical absorbents, and ammonia or brine as refrigerants. Silica gel has been used at the Wishaw installation where there are six absorber units.

Each unit consists of a large steel box in which are placed trays containing the gel in granular form, so arranged that the air passes through them in parallel. At one end of each box are valves communicating with the atmosphere or with the activating gas. At the other end are similar valves which allow either the air to pass to the blower, or the gases and water vapor to pass to a small exhaust fan used for activating. Five units are normally used for adsorption while the other one is being activated. The normal period for the activation of one unit is about 1½ hrs.

Between the dehydrating plant and the blower there is an adjustable inlet for atmospheric air which is used for diluting the dried air to the moisture figure aimed at. The moisture content varied over a 20-month period between 1.09 and 1.89 and averaged 1.37 grains per cu. ft.; about 2 lbs. of gel per cu. ft. of air treated per minute is used and the suction required to draw the air through was 1½ to 2 in. water gage. Forty-four references are given.

—David Wolochow, *Can. Metals & Met. Inds.*, Vol. 5, Aug., 1942, pages 230-237.

Ford Makes Magnesium

Condensed from "Chemical & Metallurgical Engineering"

A special committee of the National Academy of Sciences was formed to find new processes for making magnesium. Its conclusion was that the ferrosilicon process, which had been developed in the Canadian National Research Laboratory would give the best results with the minimum time-cost risk.

Although the work of his own engineers had pointed toward the further development of a carbo-thermic process as the most promising and economic, Mr. Ford agreed to accept the committee's recommendation that the ferrosilicon process should be used.

Early Work

Within a week after the N. A. S. Committee's visit [to the Ford plant] special iron castings were made to serve as a retort and experimental production of magnesium was started by the ferrosilicon process.

In the Spring of 1942, gas fires were lighted in the first furnace and magnesium was first produced on a commercial basis shortly afterward, less than 2 months after the first furnace brick were laid. Meanwhile, workmen were pushing construction on the next section of furnaces, and the smelter began its round-the-clock schedule to the Victory effort.

While construction tempo was proceeding, retorts of varying alloys and sizes were tested in a pilot furnace to determine the most efficient mass production setup. A 20-in. diameter was first tried, but the time required to raise the tube to the proper temperature was too long. Other diameters from 6 in. to 20 in. were experimented with and more than a thousand different runs were concluded to find the most economical methods. Eventually a retort of 22 ft. in length, with 10-in. i.d.,

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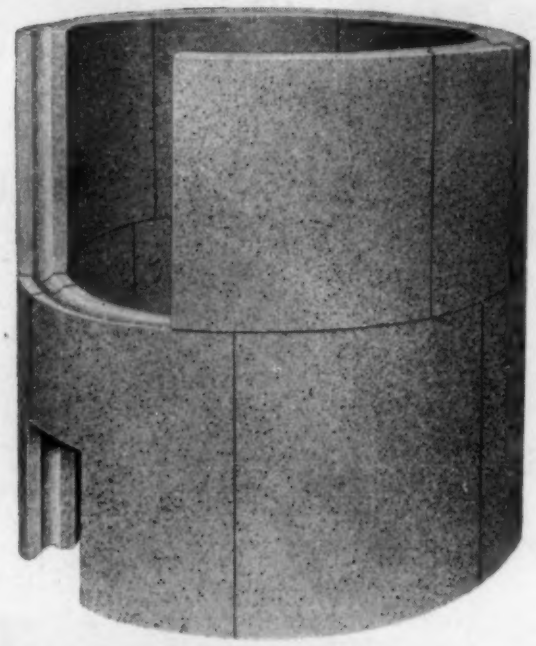

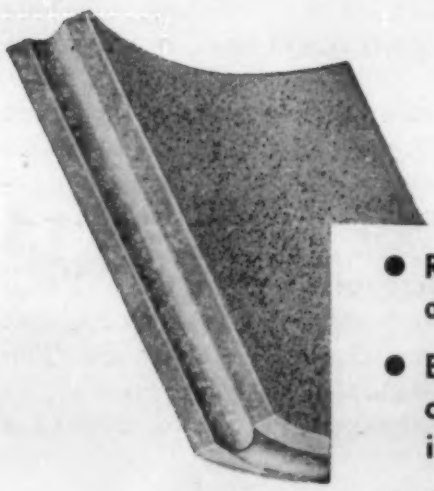

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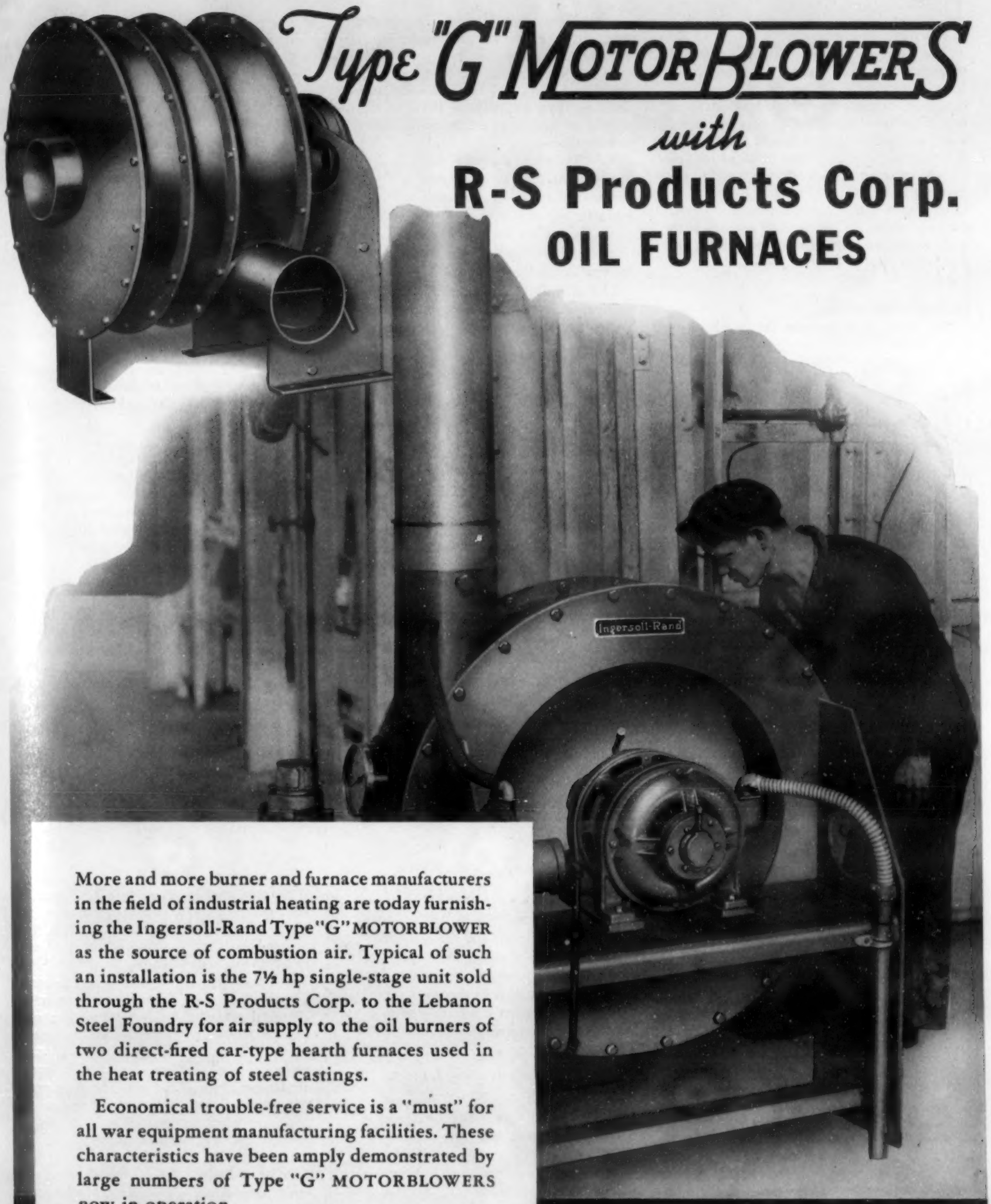

More and more burner and furnace manufacturers in the field of industrial heating are today furnishing the Ingersoll-Rand Type "G" MOTORBLOWER as the source of combustion air. Typical of such an installation is the 7½ hp single-stage unit sold through the R-S Products Corp. to the Lebanon Steel Foundry for air supply to the oil burners of two direct-fired car-type hearth furnaces used in the heat treating of steel castings.

Economical trouble-free service is a "must" for all war equipment manufacturing facilities. These characteristics have been amply demonstrated by large numbers of Type "G" MOTORBLOWERS now in operation.

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made from chrome-nickel steel, proved most satisfactory.

The ferrosilicon process of producing magnesium metal is relatively simple—at least in outline. Dolomite, the naturally occurring calcium-magnesium carbonate, is one of the most abundant of our limestones, with deposits widely scattered throughout the United States. The combination of the dolomite and ferrosilicon, properly proportioned in a vacuum at a high temperature, causes the magnesium to be driven off as a vapor. Coming into contact with a cool surface, this condenses while the iron rides along on the coat-tails of the silicon.

Production Operations

The production flow at the Ford plant proceeds in two stages—calcining and smelting. From the Michigan quarries, dolomitic limestone is brought to a former cement plant to be dehydrated, powdered and calcined. The burning process removes approximately 50 per cent of the weight of the raw stone in the form of carbon dioxide.

The calcined dolomite and precrushed ferrosilicon are proportioned into large compartment ball mills which have the dual function of powdering and mixing both materials. They further compact the mixture so that there is less tendency for segregation during storage.

This dehydrated dolomitic lime and ferrosilicon mixture is stored, transported by trucks to the magnesium smelting plant, where, in the briquetting unit, the dolomitic lime (mixed with 75 per cent ferrosilicon in a ratio of slightly less than 6-to-1) is compressed into handy shape. The finished briquettes are then ready for the smelter.

The magnesium smelting furnaces are arranged in a number of rows. Each furnace is 19 ft. high, 16 ft. wide, and 18 ft. long. Through the middle of each runs two tiers of Nichrome pipe, 11 to each furnace, banked six on the bottom row, and five on the top. These are the retorts. They are 22 ft. long, 13 ft. of which is in the heat zone, and 31 in. of which projects from each end of the furnace. Furnaces are designed to use either 10 or 12-in. i.d. retorts. These are supported inside the furnace by refractory brick arches. Split steel sleeves fit inside each retort on the ends projecting from the furnace. It is on these that the magnesium condenses and crystallizes.

Smelting in Vacuum

Smelting must be carried out in a high vacuum. This is accomplished by manifolding each retort into a vacuum pump. A 1.5-in. pipe leads from each retort and into one of four furnace manifolds, which, in turn, lead to the floor beneath each furnace where they connect with four vacuum pumps each driven by a 5-hp. electric motor. These pumps, rated at 100 cu. ft. of air per min., remove the air from the retorts. Metal caps placed over the retort ends facilitate in maintaining the high vacuum.

The briquettes are preheated above the furnace proper before loading into the retort. Furnace exhaust gases are circulated through this area on their journey to the chimney, and the briquettes are thus heated. As the retorts open for charging, these preheated briquettes are loaded into the 22-ft long tubes, the load weight per retort being 350 lbs. The end caps are then attached and the vacuum pumps started.

Each furnace is fired by numerous gas jets from each side. They burn purified coke-oven gas and maintain the necessary temperature inside the furnace. This heat, assisted by the vacuum, causes the magnesium to vaporize. An 8-hr. cycle releases the greater proportion of the metal. The vacuum, aside from its necessity in the chemical reaction, tends to draw the magnesium vapors to the ends of the retorts. Here, after some experimenting with water-cooling, it was found that cooler air temperatures at the end-tube portions of the retorts were sufficient to cause the necessary condensation. The metal is deposited on the split iron sleeves lining the extremities of the tubes.

After 8 hrs. of firing, the sleeves, with their magnesium deposits, are withdrawn from the retorts and the crystallized metal removed. Theoretically, 20 per cent of briquette weight should be deposited as magnesium. This would represent 70 lbs. of metal per charge.

Censorship prevents disclosure of magnesium smelting production per furnace per day, but it is high, and the furnace operates 24 hrs. each day on 8-hr. firing cycles.

—G. E. Stedman, *Chem. & Met. Engrg.*, Vol. 49, Sept. 1942, pages 134-137.

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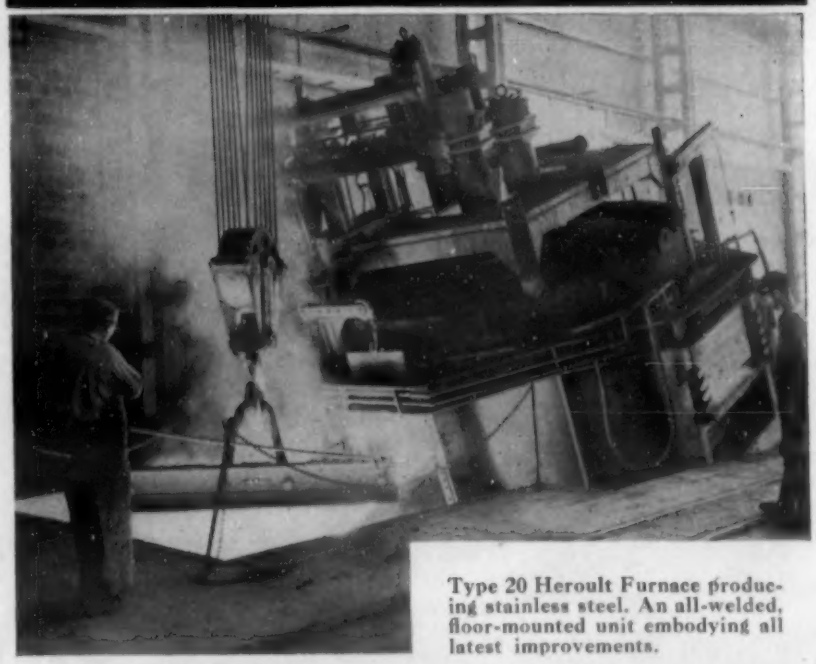

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CONTENTS

Cladding Methods in Germany 930
Arc Welding Sets 936
Electroplating on Aluminum 938
Electroplating Aircraft Parts 942
Machining Cast Armor Plate 944
Fast Surface Hardening 946
Heat Treating Cartridge Links 948
Low Alloy Steel in Aircraft 950
A Spot Welding Kink 952
Blanking and Piercing Die 952

Cladding Methods in Germany

Condensed from "Korrosion u. Metallschutz"

Under the title Plattiertechnik (Mechanical Plating Technique) a whole issue of the above journal is devoted to the manufacture, properties and treatment of clad metals, several authors writing on the developments and surveying literature exhaustively in the different fields of this technique, which has become so important in many countries in conserving valuable materials.

The so-called "compound process" is today greatly perfected; it consists in the manufacture of cast-together materials or joining them under pressure and heat. The latter procedure is widely used in Germany, and permits the building of large tanks, vats and vessels in dimensions not possible before where nickel had to be used as material of construction.

The use of compound clad materials (nickel on steel, copper on steel) makes possible considerable saving in expensive materials. Very frequently, plating with non-rusting steels is used; the likelihood of the carbon of the base material diffusing into the cladding and forming chromium carbides in the grain boundaries can be prevented by using diffusion-preventing intermediary layers.

The problem of welding plated materials has been satisfactorily solved by special welding processes; patent literature in this connection is surveyed (65 references).

E. SCHÖNE discusses questions of quality in the production and use of plated sheets. He states in general that for plating by roll-welding those metals can be used that have a melting point higher than 1400 deg. F. irrespective of whether the cladding is done on one side only or both; in the latter case, cladding materials and thicknesses can be different on both sides, according to the purpose.

Of great interest are the testing methods for determining the bonding of the clad layer to the base material. The results of such tests show that the adhesion increases with the rolling temperature (as is quite natural), and that even for copper on steel bond strengths have been found about equal to the tensile strength of copper.

Such tests are now made in special setups, at as low as —275 deg. F. and as high as 2000 deg. F. At these high temperatures, even quenching in water does not separate the plated layer from the base.

Bending fatigue tests at 10×10^6 load alternations and with loads of 20, sometimes even over 50 kg./mm.^{2} in the outermost region also did not show a separation.

Flame-cutting, which is relatively difficult with copper, nickel and stainless steels, can readily be used for clad sheets by using the following precautions: Copper and nickel-clad sheets should be cut from the clad side, inclining the flame 10-15 deg. forward, and adjusting it so that the point of the cone just touches the clad layer. Cutting velocity and oxygen pressure depends on the thickness of the copper layer; in flame-cutting nickel layers the velocity can be considerably increased.

LINDBERG FURNACES IN THE AIRCRAFT INDUSTRY

ALL THE LEADING AIRCRAFT MANUFACTURERS and subcontractors in the country employ Lindberg Cyclones for the precision heat treatment of aircraft parts. In the heat treatment of aluminum and magnesium alone, the Cyclone is ideally suited because of its heating uniformity and accurate temperature control. The high quality of the tons of heat treated stampings, castings and forgings which are turned out of Cyclones each day, is due to the famous Lindberg 100% forced convection heating principle.

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Uniform heating is the result of great volumes of air being circulated at a two-mile-a-minute velocity through the work chamber so that exactly the same degree of heat is forced to every part of the charge. Under this condition, it is impossible for damaging heat differences to exist. Repeated multiple point pyrometer tests, using 6 or more thermocouples at various points in the work chamber, show a straight line on the temperature recorder.

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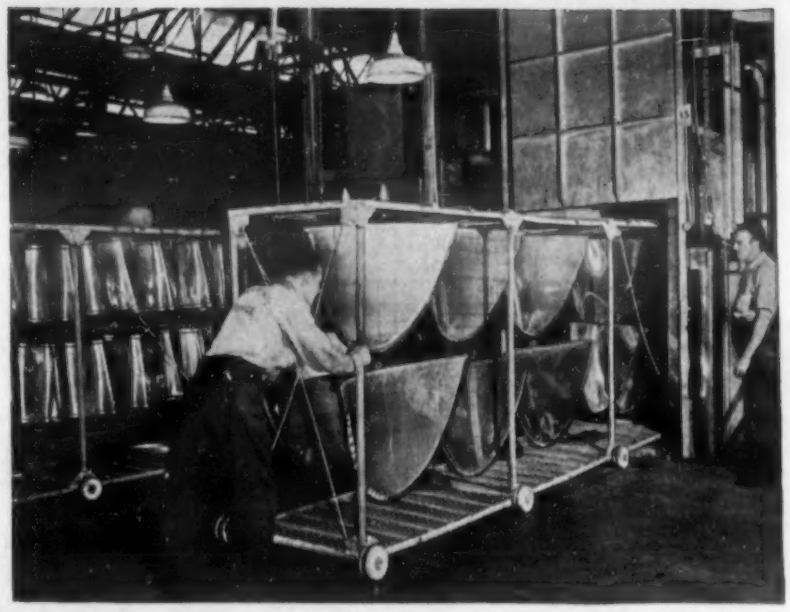
It means that production is necessarily greater because large, dense loads are heated with an assured uniformity. It means a smooth flow of non-ferrous heat treating production. It means that each piece of vital equipment is not held up because of wasteful rejection, and too, it means that you have one less production problem to worry you in these days of wartime pressure.

Ask about the Cyclone and its possibilities in your own shop. A Lindberg sales engineer will be glad to discuss your problems with you.

These furnaces for the heat treatment of non-ferrous metals have been built in a wide range of sizes, in both vertical and box type designs.

The vertical or pit type Cyclone comes in *80 different standard sizes* of varying diameters and depths. The box type Cyclone is made in *58 different standard sizes.*



Aluminum stampings, on a rack, being charged into a large, box type, Cyclone furnace for solution heat treatment.

A mass load of magnesium castings which are uniformly and accurately heat treated daily in this Cyclone box type furnace.

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These 8 "Pointers" Will Help You Get Maximum Service from Lead and Cyanide Pots . . . . .

1. Avoid direct contact of flame with pot.

2. Remove sludge from bottom of pot daily or as often as practicable. The life of the pot is in direct proportion to the frequency with which it is cleaned out.

3. Furnace atmosphere around the pot should be pyrometrically controlled to prevent pot exterior from exceeding 2000°F. Amsco Alloy begins to slowly oxidize above this temperature.

4. Do not exceed thermal capacity of bath. Pyrometer inside of pot should be carefully watched because an excessive drop in temperature indicates cold material is being charged in excessive quantities and too frequently. High rates of firing are then required to bring up the temperature, which reacts unfavorably on the pot exterior.

5. Baths should be brought to operating temperature as slowly as possible.

6. Use an effective seal between pot rim and furnace rim to prevent spillage or "creeping" of salts. Combustion products of all heat treating salts are highly corrosive and cause rapid deterioration of pots and furnace linings. Inspect frequently to make certain salts are not reaching outside of pots.

7. When furnace is not in operation, such as overnight, keep burners on enough to prevent solidification of bath. Extended pot life and savings in time required to bring both back to operating temperature will more than offset cost of fuel.

8. Where firing conditions make impingement of flame on pot unavoidable, it is advisable to turn pot occasionally, so as to expose all sides equally to the higher temperature at the point of impingement.

Typical units are shown: R-433, a 20"x20" cyanide pot of Amsco Alloy grade F-1. C-560, a lead pan of grade F-10. Beside pots, carburizing containers of unit and sectionalized design, trays, muffles, retorts, conveyor chain and furnace parts are available of laboratory controlled, X-ray checked, Amsco Alloy. Amsco metallurgists and engineers have helped, in an advisory capacity, to convert the heat treating equipment of many plants to war production. Send for Bulletin 1041-A.

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Sheets clad with rustless or acid-proof steels are best cut from the base-metal side, whereby the burner is inclined 12 deg. opposite to the cutting direction; the starting point should be well preheated. Of the utmost importance is surface treatment, as defective surfaces give easy rise to corrosion. Proper cleanliness of the surface is best obtained by mechanical treatment, especially grinding.

Chemical properties of plated sheets and their welds are treated by W. RÄDEKER. Only those metals assure a good bond with the steel base that are uniform in structure and pure; especially should they be free of oxygen and sulphur as these two elements prevent good metallic joints by forming separating layers.

Also heterogeneous constituents at the grain boundaries impair the cladding as they hinder the transmission of bond-pressure to the base. Carbonyl nickel, additions of manganese to copper and nickel and of nickel to silver have improved the quality of the clad layers so much that they are now always employed.

In order to prevent harmful stresses in the (usually thinner) clad layer and between cladding and base the linear heat expansion coefficients should be as nearly equal as possible; the table shows these coefficients of steel and those of its most important cladding metals.

Material	Temperature Range °C.	Expansion coeff.	Conformance (steel-100)
mild steel (0.15% C)	0-500	0.000014	100
copper	0-500	0.000018	130
nickel	0-500	0.000014	100
Cu-Ni stainless (18-8)	0-500	0.000017	120
Cu-stainless (17%)	0-500	0.000013	93
Monel metal	0-500	0.000015	107
silver	0-500	0.0000195	140

Tests (by dissolving in acid) have shown, however, that these differences have no harmful effect on corrosion resistance. An investigation of the chemical resistance of welds on plated materials has shown in all cases that correctly made welds have the same resistance against chemical attack as the solid coating material, so that experiences with the latter can be directly applied to clad sheets.

KÖHLER devotes his contribution to the testing and rating of semi-finished products which he discusses and explains on the basis of many metallographic studies, using quite diversified testing methods and materials. He finds that soft iron which is to be clad with copper should possess the following qualifications: It should be mechanically, structurally and in its shape fully suitable for the intended purpose (deep-drawing, bendability), and resistant against clad layers coming off; the clad layer must be sufficiently thick to avoid corrosion of the base metal.

In order to avoid formation of coarse grain in soft annealing, a cold-deformation of 25 per cent is recommended. The copper for cladding should be of more than 99.9 per cent purity, with 0.03-0.06 per cent P.

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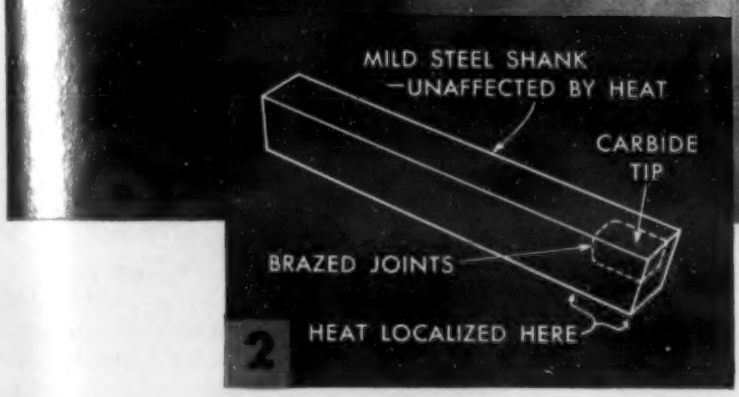
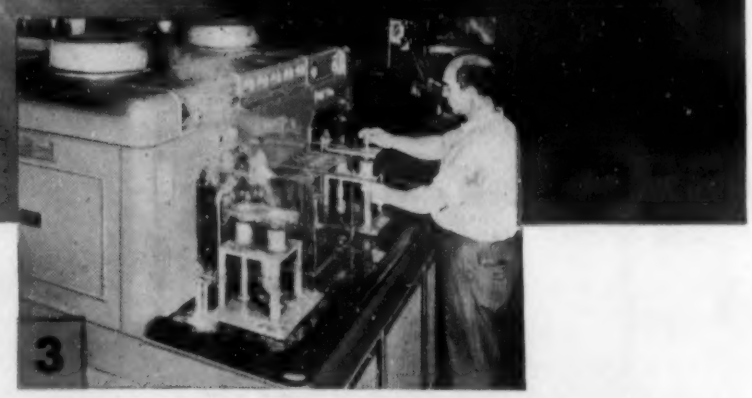
Adapters are being silver-soldered in 4.2″ mortar shells at the rate of 20 seconds per shell by TOCCO Induction Heating. The base also is silver soldered by TOCCO. Rapid and localized heating maintains the original physical properties of the shell.



Another TOCCO-brazing application. Carbide tips are brazed to mild steel tool shanks by TOCCO Induction Heating as shown. Rapid heat, confined to brazed zone, produces tight, uniform brazes.



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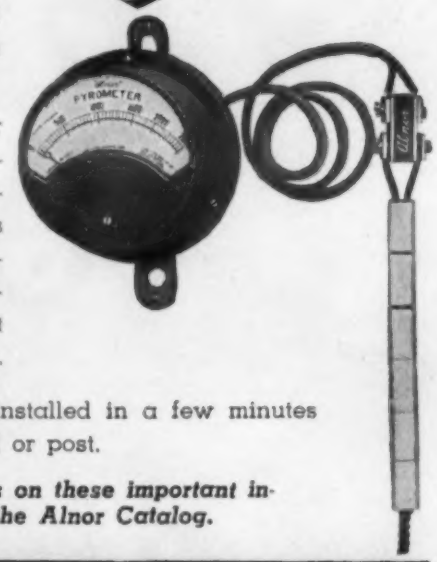

The Alnor No. 1705 Pyrometer is a reasonably priced instrument designed for lasting service in high temperature ranges . . . Heavy-duty type thermocouple is provided with a protection tube to allow for direct immersion in the molten metal.

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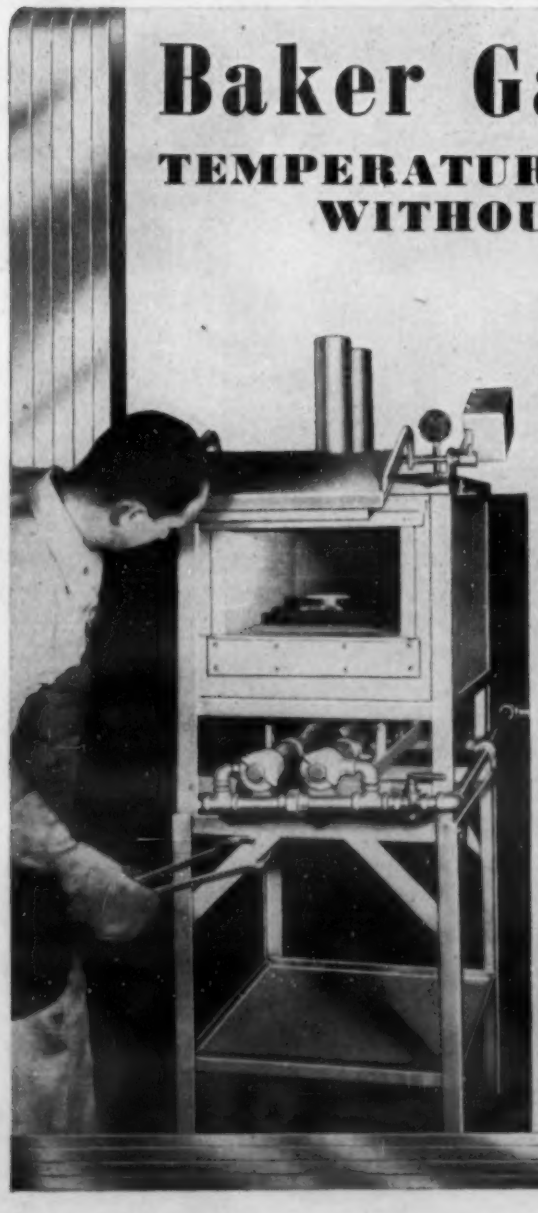

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The special requirements for furnaces for heating the materials to be rolled together to welding heat and protecting them from oxidation are discussed at length by K. SCHERZER. Electric resistance and also induction heating are used, the latter at normal voltages and frequencies for heating pressure vessels, whereby the walls of the vessel are heated by induction.

The very interesting question of recovery of valuable metals from the scrap and waste in the manufacturing processes is discussed by W. MACHU. As the thickness of the plated layer is between 3 and 60 per cent (in general, about 10 per cent) of the basis metal the saving is worthwhile. A review is made of the processes to recover the clad material and of the relevant patents. Chemical and electrolytic methods are generally applied.

—*Korrosion u. Metallschutz*, Vol. 17, Feb. 1941, pp. 41-72.

Arc Welding Sets

Condensed from "General Electric Review"

A systematized maintenance program for arc-welding sets will pay dividends in better performance and longer life. The right welding set must first be selected. The maximum current, load voltage, and duty factor (ratio of arc time to total time) must be considered. Most sets are rated on a one-hour load.

Proper installation can do much to keep the welding equipment at work and troubles at a minimum. Adequate branch-circuit conductors and large enough fuse clips should be provided.

Frames of all welding equipments should be grounded and adequate low-resistance work leads should always be used. There should be good connection between the work lead and the work as otherwise the ground connection may become overheated.

Overheating, which shortens the life of electric insulation, is bound to result if there is insufficient ventilation. If necessary, large louvers or other ventilating openings should be provided to keep the ambient temperature below 100 deg. F.

Inspection records, showing all repair work with its cost, should be kept. These serve as a guide to welding sets requiring excessive attention or expense, proving they need either corrective measures or replacement.

A systematic inspection of motors and generators is necessary to insure best operation. If conditions are extremely severe, weekly inspection and partial cleaning are desirable. Most motors require a complete overhauling and thorough cleaning once a year.

Arc welding transformers of alternating-current welders require a minimum of maintenance but should not be neglected. Fans should be cleaned and lubricated once a year. Windings should be blown out at least twice a year in very clean locations and more often in dusty places. At the same time all connections and coil supports should be checked for tightness. Manual current-adjusting mechanisms should be lubricated often enough to prevent stiff

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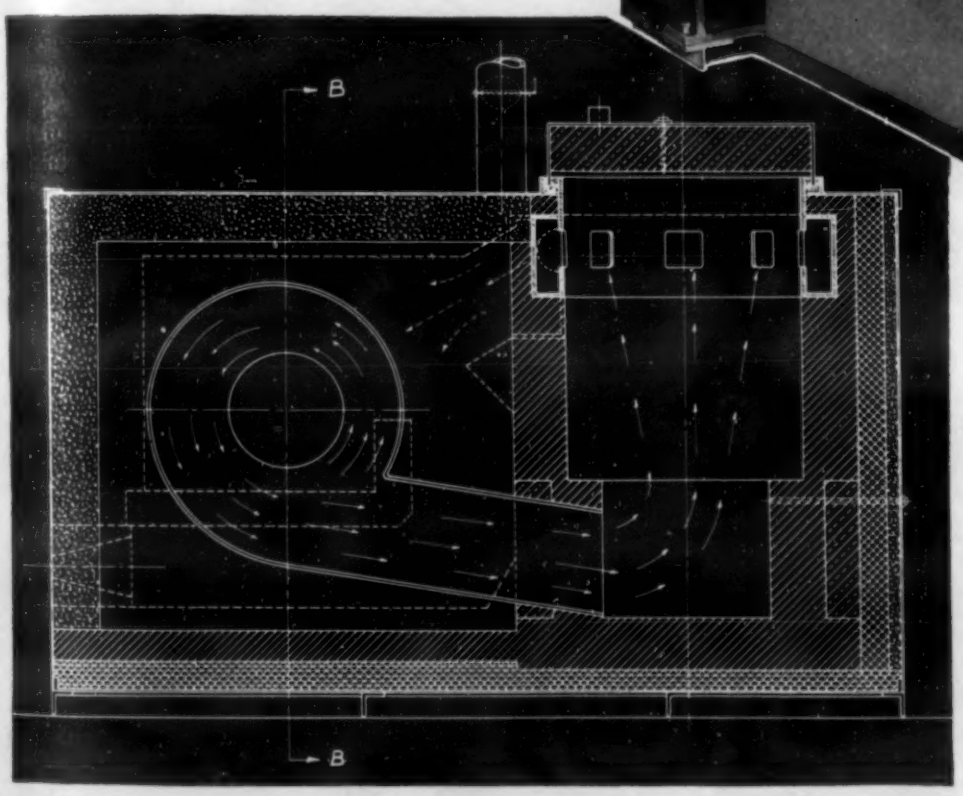
LONGITUDINAL CROSS-SECTION VIEW showing arrangement of blower, ducts, and cylindrical treating chamber, with collector ring at top proportioned for *uniformly even* flow of air back to heating chamber for recirculation.



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Construction is of mild steel casing with removable top for easy access to inside.

Self-Sealing Lid for heating chamber provides a tightly sealed joint when closed, and also locks itself in position when open. It is an extremely easy working mechanism.

Fan, Shaft and Duct are of special heat resistant alloy steel. Fan on shaft cools shaft bearing.

Lining is best grade refractory. Cover is lined with castable refractory insulation. Treating chamber is walled with fire brick.

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operation. On motor-operated controls, more frequent lubrication may be required.

Abuses which often cause serious impairment are: Covering machines in operation so as to prevent proper ventilation; improper connection of extension leads for either the electrode or work terminals; the intentional or unintentional application of long, continued short circuits on the generator; the use of improperly bonded structural-steel systems or building frameworks for the welding-current return circuit; rough handling in transportation; use out of doors without protection from unfavorable weather.

A table published with this article gives the causes and remedies for the majority of troubles which occur in using welders.

—R. F. Wyer, *Gen. Elec. Rev.*, Vol. 45, Aug., 1942, pages 438-442.

Electroplating on Aluminum

Condensed from "Light Metals"

Electroplated finishes on metals, while formerly applied in a more or less haphazard manner mainly for decorative purposes, have been expanded in recent years to engineering uses where specifications of process and thickness are closely defined. In line with this trend, there has been a greater diversity not only of the plating metal, but also of alloys plated.

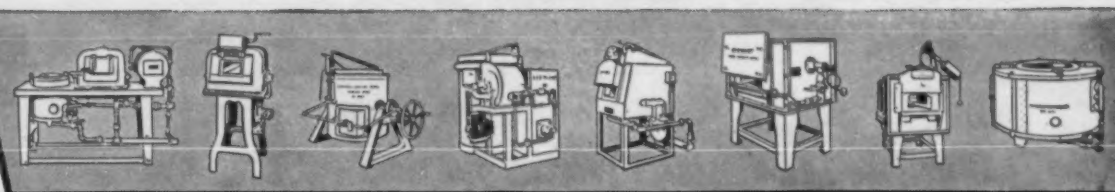
Aluminum alloys (excepting only magnesium alloys) present more difficulty to the electroplater than other common engineering metals. In fact, the difficulties involved have prevented a widespread use of electroplated aluminum alloys. However, these difficulties have been exaggerated, for there are ample operating data available for the successful electroplating of aluminum by a variety of methods; it is practicable to plate by barrel or still vat, in rotary cathode equipment, or in automatic plant.

In these times where one metal is being constantly substituted for another because of changing shortages in raw materials, it is imperative for forward-looking electroplaters, to be aware of the possibilities which new methods or enforced substitutions may bring. Post-war conditions will almost certainly see a tremendous expansion in the use of aluminum alloys, with a corresponding demand for a broadened range of protective coatings.

The Practical Obstacles

Practical difficulties in the electrodeposition of aluminum are associated with the strongly electropositive nature of the metal, and the refractory aluminum oxide film which is always present on the surface. When a piece of cleaned aluminum is placed in a solution of some less electropositive metal such as nickel, for example, the surface of the aluminum commences to dissolve, and the nickel deposits on it. Because the chemically deposited metal is apt to be non-adherent and spongy, the electro-deposited metal is plated on a "moving surface," and it, too, is non-adherent to the base metal. Placing the work already connected into the bath is not very practicable. Work entering the plating solution is coated with an oxide film, and

NO. 22 OF A SERIES OF TYPICAL INSTALLATIONS OF



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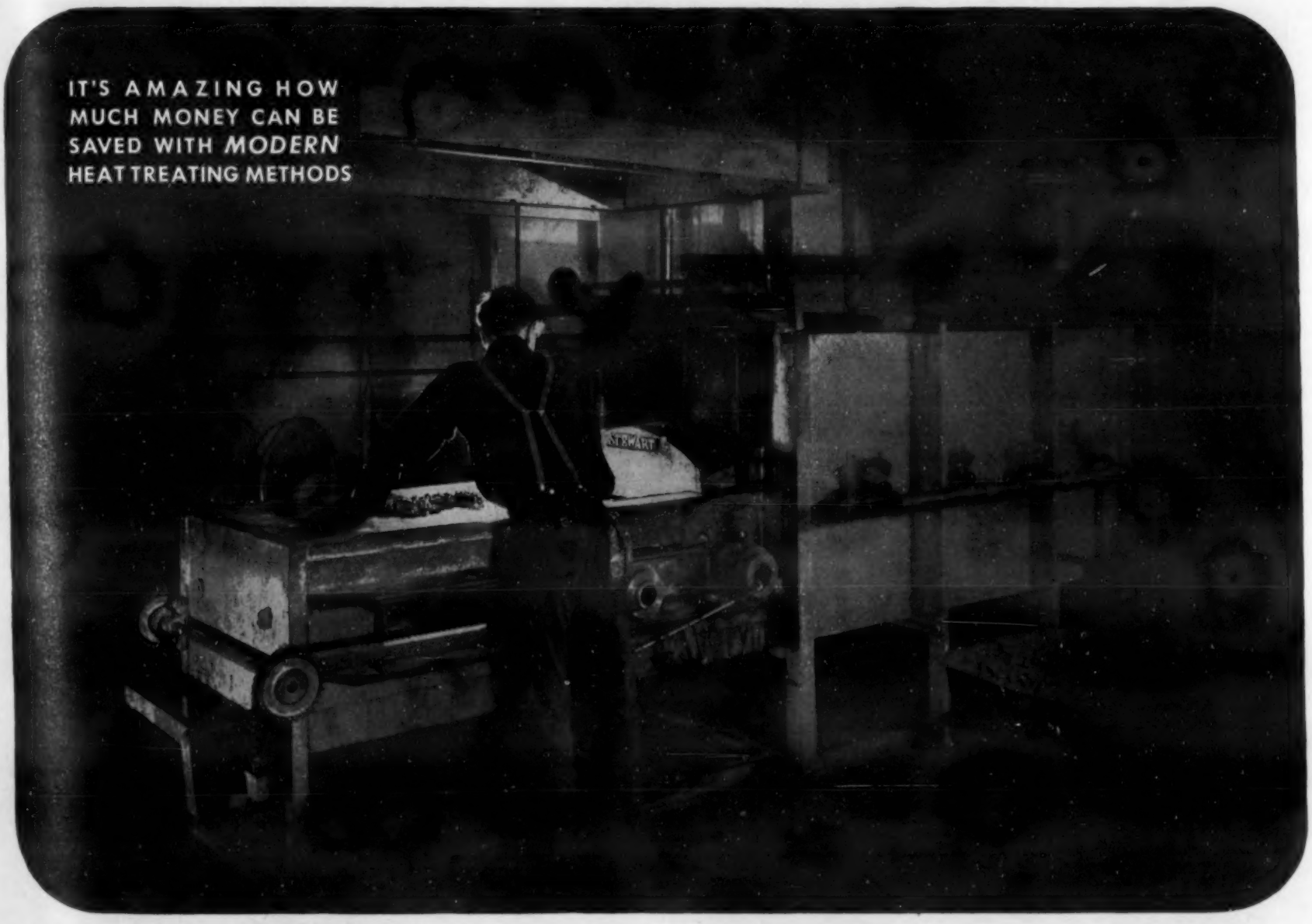

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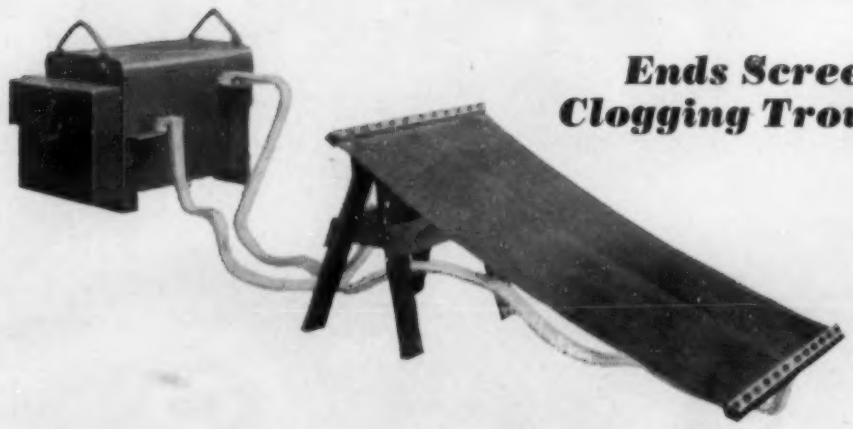

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in order to secure satisfactory platings, this oxide film must be removed.

Special pre-treatments have been developed to prevent both spongy chemical deposition and to remove the oxide film. In spite of the fact that zinc is electronegative to aluminum, zinc in contact with aluminum has been found capable of "sacrificial action" in saline atmospheres, equivalent in effect to the protection offorded iron and steel by zinc. In many cases, however, even if zinc by corroding first would always serve to protect aluminum, the service requirements, usually demand a metal essentially unattacked by the environment. In this case, where a nickel coating might be used, the latter must be pore-free or attack on the aluminum more severe than in the absence of the nickel would be expected.

The same would occur with copper or almost any steel markedly electronegative to aluminum. Therefore, the nickel plate, the usual choice for the first plate on aluminum, must be thick and continuous. A flash of chromium is often applied as a finishing coating; the chromium coat, as is well known, adds tremendously to the corrosion resistant properties of the nickel plate, disproportional to the thickness of the coat (probably because of the passivity induced in the nickel by the chromium electrolyte).

The chromium flash is not applied where other metals are to be used for the final plate. When silver, gold, rhodium or platinum are needed for electrical reasons etc., the required thickness can be applied over the nickel. Prior to treatment in the electroplating line, the usual cleaning operations are performed. If corrosion products are present, they can be removed with 5 H_2SO_4 solution at 60 deg. C. (140 deg. F.). After the acid dip, if special surface treatment is required, such as shot blasting, polishing, etc., it can be done at this stage.

Cleaning and Plating

The plating line itself comprises: (1) An alkaline dip; (2) a preparatory treatment which may be a metal dip, or an acid treatment, or a simultaneous degrease and metal flashing operation and, (3) plating proper, which may be followed by orthodox plating, or a total coating.

Each step is followed by thorough washing in water. The alkaline dip is used to eliminate "finger marks" etc.; it completely wets all surfaces, and is important to the successful sequence of operations. It may be ordinary or electrolytic. A solution of 2 oz. each of sodium carbonate and trisodium phosphate per gallon of water with an immersion time of 1 to 3 min. at 80 deg. C. (176 deg. F.) is recommended for a wide range of work. An acid dip often follows to remove traces of the alkali. This dip may consist of 5 to 10 per cent (50% HF) in water. However, if the electroplating bath is an alkaline one, there is probably no need for the acid dip. The most common practice has been to use a so-called "metal dip" after the hydrofluoric acid dip referred to above as a preparatory treatment for electroplating.

The most commonly used was the "iron dip," and one such bath consisted of the following:

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In order to relieve stresses between draws, brass shell cases are conveyed by basket through a continuous annealing-pickling operation pioneered by the Army Ordnance.

Annealing furnace temperatures are maintained at over 1100° F.—into which the loaded baskets move directly from room temperature. Immediate cooling with cold water spray follows annealing. Oxide scale is then removed by immersing the basket of shell cases in fully aerated pickling solution containing about 10% sulphuric acid and 2.5% copper sulphate, at a temperature of 160 to 180° F.

In this continuous operation baskets of welded Inconel construction have proved exceptionally effective. One of many metals tried for the annealing-pickling baskets employed, it has served over 3,000 furnace hours, plus the necessary number of pickling cycles. Few metals formerly used could withstand more than 700 to 900 hours . . . and in that length of time required considerable maintenance, against virtually none for Inconel. It should be noted that these other metals were used chiefly in the form of castings.

The details of this case history have been published in the belief that they will be of interest and value to engineers and designers who are working on similar problems, as well as for those who are planning for the future.

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90 to 95 deg. for 10-60 sec.

While the "iron dips" have been used for general purpose work, it is generally considered better to use a nickel dip if the electroplating is to be nickel. A satisfactory nickel dip contains:

Nickel chloride crystals	7 to 8 oz.
Hydrochloric acid (conc.)	0.04 gal.
Water	1.0 gal.

As for nickel plating solutions, one of the most commonly used contains the following (sodium sulphate loaded bath):

Nickel sulphate crystals	16 oz.
Sodium sulphate crystals	26 oz.
Ammonium chloride	2 oz.
Boric acid	2 oz.
Water	1 gal.

This bath operates cold or up to 30 deg. C. (86 deg. F.) with 5 to 15 amps. per sq. ft. with pH 5.2 to 5.6.

While some workers have advocated heat treatments of the order of 6 hrs. at 150 deg. C. (302 deg. F.) following plating to secure better adherence, this procedure should not be necessary. In cases where a sodium zincate bath is used as a modified metal dip, the same nickel solution can be used for plating. Much work is plated on a zinc flash, which is a simultaneous cleaning and plating, operated at high current density. The solution contains:

Sodium cyanide	2 oz.
Zinc carbonate	2 oz. 149-167 deg. F.
Caustic soda	1 oz. 30-60 sec.
Water	1 gal. 10-12 amps. per sq. ft.

This treatment is said to strip the oxide film and to deposit zinc on the cleaned aluminum simultaneously. The regular nickel plating procedure may then be applied.

Three procedures of pretreatment are cited which actually proved to be satisfactory, in shop operations. One of these, the nickel chloride dip method (described above) follows in detail:

1. Alkali clean by immersion 3 min. 80-85 deg. C. (176-185 deg. F.) acq. solution 0.2 oz. each of soda ash and trisodiumphosphate per gal. of water. Cold water rinse.
2. Acid treatment by immersion 15 sec. 5 per cent HF (by vol.) room temperature. Cold water rinse.
3. Nickel chloride dip 15 sec. 30 to 35 deg. C. (86-95 deg. F.) in solution of: Nickel chloride crystals 7.25 oz., HCl conc. 0.04 gal., water 1 gal. Cold water rinse.
4. Nickel plate in the sodium sulphate loaded electrolyte at 10 amps. per sq. ft. for 20 min. or upwards depending on the thickness of the deposit required.

Test samples stood a 90 deg. bend without flaking, and the adhesion generally was very satisfactory.

Anodizing Pre-treatment

The anodizing pretreatment method was developed originally in Germany and is used rather extensively in the United States. Anodic oxidation treatment is carried out in an oxalic acid solution containing 0.4 to 5 oz. oxalic acid per gallon of water. The clean work is anodized from a low voltage to 50 volts for 10 min., keeping current density below 5 amps. per sq. ft. The electrolyte is cooled, if necessary, to maintain a temperature of 16 to 20 deg. C. (60-68 deg. F.). After washing and immersion for 14 min. in a solution of 8 to 10 oz. sodium cyanide per gal. of water, it is washed again prior to being transferred to the nickel plating solution.

The exact time of the sodium cyanide treatment is the critical feature of the process, and is learned by experience from the surface appearance of the anodized surface. [*This patented method is known as the Krome-Alume process or the Travers process, and is widely used in the United States. It is said to be one of the best, if not the best commercial method available today for the preparation of aluminum alloys for electroplating. AUS.*]

Summarizing, the following generalizations can be made:

1. The metal dips, particularly the iron, give consistently good results; but the nickel dip is worthy of greater consideration than it has received in the past.
2. The sodium zincate dip is an advance on the older metal dips, and is a notable contribution to the art.
3. Direct plating, including high speed flashes from electrolytic alkaline baths, are not recommended.
4. The anodic treatment requires more experience before its value can be properly appraised.

—*Light Metals*, Vol. 5, Aug. 1942, pages 322-330; Sept. 1942, pages 368-370.

Electroplating Aircraft Parts

Condensed from "Monthly Review," Am. Electroplaters' Soc.

The most used kind of plating in aircraft manufacture is anodizing. A chromic acid bath containing 5 per cent chromic acid, operated at 95± 4 deg. F., is commonly used. Chloride and sulphate content must be limited; 40 volts and a current density of 1.5 to 2 amp. per sq. ft. for 30 min. are commonly used. Sulphuric acid anodizing baths are prohibited on parts which are subject to stress and which contain joints or recesses in which the anodizing solution may be retained, but may be used on other parts.

A mild alkaline cleaner which will not etch the aluminum is used in preparation of parts for anodizing. A solvent precleaner may be used but is not actually necessary.

A substitute for anodizing consists in oxidizing the aluminum by dipping in a "Chromadizing" bath, or by using the "Alrok" process, which involves dipping the aluminum part in a nearby boiling solution of sodium carbonate and potassium dichromate for 30 min., followed by a sealing dip in hot 5 per cent potassium dichromate.

Coatings produced by the latter methods do not give as good protection as anodized coatings but are cheaper and are satisfactory for land-based planes. Anodized coatings are tested by the salt spray. Anodizing is used for inspection by utilizing its property of accentuating the visibility of cracks in aluminum forgings.

Steel parts are protected almost universally by cadmium plating, which has been found to be more resistant to salt spray water than zinc. Thickness of plated cadmium is usually 0.0005 in. Army-Navy specifications require that no undercoating be used under cadmium. Most plated steel parts are small, but sometimes en-

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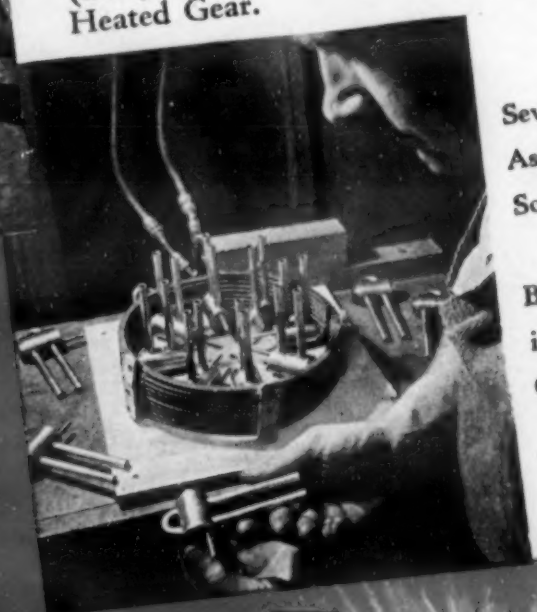

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tire welded steel fuselage frames are cadmium plated.

Hard chromium plating is applied to hydraulic parts such as cylinders, pistons and piston rods used for such things as hydraulically operated wing flaps and retractable landing gears. Piston rods must be highly polished before and after plating to prevent excessive wear on rubber packings. Copper is plated as a "stop-off" for selective case hardening. Rivets are sometimes tin plated because tin-plated rivets can be driven in without destroying the plate. Zinc plating is not much used but may become necessary as a substitute for cadmium.

—R. R. Janssen, *Monthly Rev.*, Am. Electroplaters' Soc., Vol. 29, Aug., 1942, pages 676-686.

Machining Cast Armor Plate

Condensed from "American Machinist"

Armor plate castings cannot be machined like ordinary steel castings or forgings. Although armor plate may vary widely in analysis and machinability (since the term is merely a ballistic definition), a number of general considerations apply to almost all armor plate castings requiring machining.

The gates are generally removed by flame cutting, thereby frequently leaving an extremely hard glassy surface. Secondly, most castings of this type have irregular contours and require interrupted cutting. A third problem is that the casting is usually covered by a hard scale. It is more usual than not to find hidden sand pockets and extremely hard inclusions. An outstanding difficulty is that this tough hard material has a tendency to work harden, so the tools must be as free cutting as possible. Also, armor plate castings flex more easily under pressure than ordinary steel castings, returning to their original state when the pressure is released.

Machining equipment (largely vertical boring mills, vertical turret lathes and large engine lathes) must be sufficiently rugged to withstand the shock of interrupted cutting and the drive motor should have ample power to pull the maximum number of tools, even when the latter are somewhat dull. Experience has generally shown that it is best to tool up on the basis of sintered carbide tools.

At the slow speeds (about 25-30 ft. per min.) necessary with the high speed steel tools, production becomes extremely erratic while down-time is excessive since the tools have to be changed continuously for regrinding. However, on multiple turning, for example, high speed steel can be advantageously used along with carbides if one tool is working on a large diameter and one on a fairly small diameter.

Carboloy 78-B is most successful for average conditions; this grade can be used for both continuous and interrupted cuts, as well as for both roughing and finishing. Since carbide tools can finish cut through scale more effectively than other tools, the armor plate can be cast closer to size.

Shank materials may be SAE 1050, 1095, 2340, 9250 or any low alloy type. Suitable tool design and angles are discussed in detail. As a start the following angles are suggested: Side cutting edge 15 deg., back rake 0 to —3 deg., side rake 10-25 deg. (for interrupted cuts +5 to —3 deg.), (double negative rake angles are generally objectionable), end cutting edges 8 deg., nose radius 1/16 in. for continuous cuts, 3/32 in. for interrupted cuts, relief 7 deg.

Chip breakers in general are undesirable for single point tools, unless the chips are hazardous to the operator or ruin the finish, as they reduce tool life due to the increase in the already high chip pressure on top of the cutting edge. A chip curler, however, is preferable to a chip breaker. If a chip curler is used, it is important that the dimensions be maintained on regrinds.

Clamping pressures should not be excessive. Tool overhang should be a minimum, especially for interrupted cutting. A longer tool life is obtained if the cutting is done dry. If accuracy of dimensions is of prime importance, a coolant should be used to prevent warping of the casting as a result of its absorbing heat during cutting. It is usually best to use as deep a cut as possible (up to ¾-1 in.) with a suitable feed.

Cutting speed depends on other factors as well as on hard spots, etc. It is ques-

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tionable if carbide tools should be used even on interrupted cuts if the maximum obtainable speed is under 75 ft. per min.; in such cases, high speed steels are preferable.

Silicon carbon grinding wheels are suggested for routine grinding. Grinding should be done by experienced personnel and not left to individual operators. Hand stoning of the cutting edge is recommended to increase tool life. The quickest way to see if the tool is dull is to observe sharply the chip color; if the chip becomes reddish or streaky in color, the tool is dull. Planning charts are of great assistance. If it is possible to take a single cut, multiple cuts should be avoided, but in any case 0.045 to 0.060 in. should be left for finishing.

—F. W. Lucht, *Am. Machinist*, Vol. 86, Sept. 17, 1942, pages 1023-1038.

Fast Surface Hardening

Condensed from "Metal Progress"

Recently means have been found to concentrate heat from the combustion of premixed gas and air, as well as to accelerate rates of heat transfer to the work from gas-air burners in open arrangement. As a result, localized heat treatment, burning commercial gas, carbureted with air, in widely used combustion control machinery, is now practicable.

Success with gas-air flame hardening is based on superheat or radiant combustion. Precision refractory surfaces are provided in both, in contact with which burn numerous jets of pre-mixed gas and air. This develops a uniform incandescence over the surface of ceramic walls.

The distinction between the two methods is based on the manner of using the radiant heat. In the superheat type, the two radiant walls face each other, and constitute a small ceramic enclosure with a constricted outlet which encases the combustion reaction. Thus the radiant heat acts almost wholly to accelerate the rate of reaction. This superheats the burning gases so that the temperature of the blast from the outlet slot is at least 250 to 300 deg. F. higher than otherwise attainable by more conventional methods.

In the radiant type, the radiant energy developed at the ceramic surface impinges directly upon the work piece and accelerates the rate of heat transfer from the burner to the part being heated. To do this the incandescent surface is arranged as a bowl-like cavity which faces the work at close range. The incandescent surface can be maintained at temperatures as high as 2850 deg. F., and it transfers the radiant heat rapidly.

Special burners have also been designed featuring superheated, radiant and conventional combustion. One of these is a continuous superheat burner for hardening skate blades, which permits much of the radiant energy to impinge directly upon the blade.

The largest true superheat type delivers 1,000,000 B.t.u. per hr. despite the fact that it measures only 17 x 13 x 7 in. outside. It has 5-zone control and a narrow outlet-slot about 15 in. long shaped in refractories. This burner is used for hardening alloy treads on caterpillar track shoes.

Successful performance is contingent on an air-gas mixture at 1 to 2 lbs. per sq. in., and a supply which is quickly and easily controllable. Utilization of such burners near the limits of their capacity is recommended.

Open superheat burners arranged in spirals within multi-station automatic machinery have been used for hardening armor-piercing shot on schedules of 6 to 12 min. with fuel consumption about 35 and 125 cu. ft. of natural gas per piece. Even these figures have been cut by adapting miniature radiant bells which fit a single rotating shot which may be brought to about 1600 deg. F. in 3½ min., or to 2200 deg. F. in 8 min.

For hardening anti-aircraft gun parts, a recently developed machine has each burner mounted with a double-swivel connection so it can be turned in any direction. It has been used to harden 18 different parts. Advantages claimed are that the equipment eliminates oxygen cylinders and generators, and reduces investment, operating and maintenance costs.

It has been reported that neither the superheating nor generation of radiant heat in open burner arrangements produces temperatures at any point sufficiently high to overheat sharp edges and small projections

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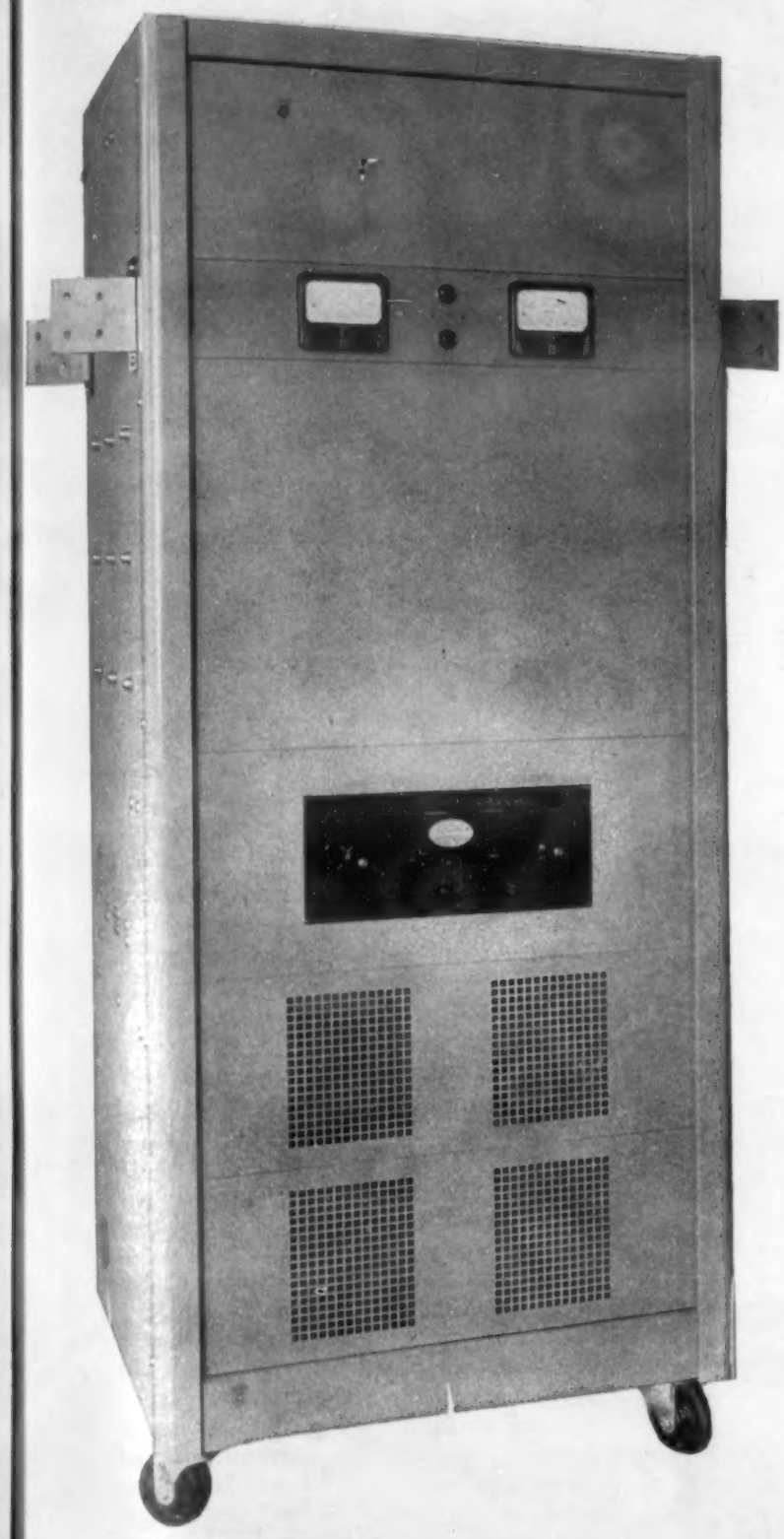

MATERIALS

This Selectro-Plater delivers 1800 amperes at 12 volts for *electro-plating. It weighs only **1800 pounds** complete—a saving of up to **70%** in copper and steel.

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Efficiency of 65% to 75% **maintained** from full load down to 10-15% of full load. Instantaneous start and stop permits **shutdown between loads.** Power factor over 0.95.

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Total floor space required only 6 square feet—a saving of up to **95%** in working space. No additional space is needed for auxiliary equipment.

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Mobile unit—**roll** into place. No special foundations or framework, no riggers. Shift to new location quickly at any time.

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Starting equipment, voltage controls, protective devices, supervisory lamps, meters—**all** in one cabinet. Simply connect to power supply and tanks—and it is ready to produce.

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For 20KW DC output only two small motors totalling ¼ hp. All major parts are static and not subject to wear. Negligible maintenance, no periodical overhaul, no replacements, unlimited life.

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* *Write for illustrated booklet showing more types. Selectro-Platers are built for 6, 12, 18, 24, 36, 48 volts and higher in current ranges from 15 to 3000 amperes and higher. Units are engineered for electro-plating, electro-cleaning, electro-polishing, anodizing, etc.*

W. GREEN ELECTRIC CO., INC.

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of steel parts, even during protracted exposure. Another claim is that, in hardening of gear teeth by the spinning method, speeds of rotation may be reduced and the heat penetrates between teeth without burning their outer edges.

The most characteristic difference lies in the transition zone of metallurgical structure from hardened surface to soft core. In two comparable parts hardened by induction heating and by the gas-air method, the difference lies in the rate of transition from hardened core to soft core. In the induction-hardened piece the Rockwell drops 20 points within ½ in. In the gas-hardened item, no two adjacent ½ in. sq. areas differ by more than 3 or 4 points.

One of the biggest possibilities lies in the developing of physical and metallurgical characteristics according to a predetermined pattern.

—Frederic O. Hess, *Metal Progress*, Vol. 42, Sept. 1942, pages 399-403.

Heat Treating Cartridge Links

Condensed from "Heat Treating and Forging"

Cartridge links for 0.50-caliber machine-guns are made to precision measurements with very close tolerances. The links are formed from coils of cold-rolled annealed strip steel containing 0.59-0.74 C, 0.40-0.60 Mn, 0.30 maximum Si, 0.05 maximum S, and 0.04 per cent maximum P. The tensile strength of the steel must be a minimum of 65,000 lbs. per sq. in. and elongation, a minimum of 20 per cent. Hardness must be 70-80 Rockwell B.

The structure is to be completely spheroidized with no evidence of free lamellar pearlite. Decarburization may not exceed 0.0005 in. maximum. The steel must be relatively free from non-metallic inclusions, and must withstand a 180-deg. bend without fracture.

Uniformity of steel is necessary in processing operations. The structure of the strip steel comprises spheroids of cementite in a ferrite matrix. One authority asserts that variations in spheroidized structure may result in clips which are incorrect in size. Another states that grain size is more important than carbide size. Experience indicates that the presence of pearlite and variation in microstructure and strip thickness may necessitate adjustment of the dieing machine.

Forming operation is extremely intricate, requiring constant attention and maintenance of both die and machine. The progressive die has eight units, any one of which may be replaced. The finished link requires eight operations before it is fully formed. Links fall directly on to a conveyor.

After cleaning, the links are transported to a belt-type radiant-tube gas furnace, provided with controlled atmosphere. It is divided into heating and soaking zones, each with its own temperature recorder and automatic control. Capacity is 1000 lbs. per hr.

There is a definite relationship between time, temperature, and quench hardness which must be determined for the particular equipment. The links remain at 1550 deg. F. for 15 min. in the furnace mentioned above. This assures complete solution of cementite and consequent formation of austenite and gives a hardness of 63-65 RC for the quenched link.

The links are piled on each other a few inches deep as they pass through the furnace and not in an ideal single layer. To insure uniform heating, the load is distributed evenly on the conveyor. Rated heating capacity of the furnace is not exceeded, as experience showed that rejects which can be attributed to insufficient heating increased with the load.

Links are discharged into a chute extending from the furnace to several inches below the surface of the quench oil in a 3000-gal. tank. Oil is kept at 125 ± 5 deg. F. There is a large pump for circulating the oil and discharging it below the chute, at the same time producing necessary agitation for a speed quench. A smaller pump passes a part of the oil through a cooler and eventually discharges it into the tank.

The quenching operation is very important. In one case it was found that the cooling rate obtained in practice was slower than the critical cooling rate of the steel. Fully hardened links were obtained by increasing agitation of the oil in the chute and by raising the hardening temperature from 1500 to 1550 deg. F. In

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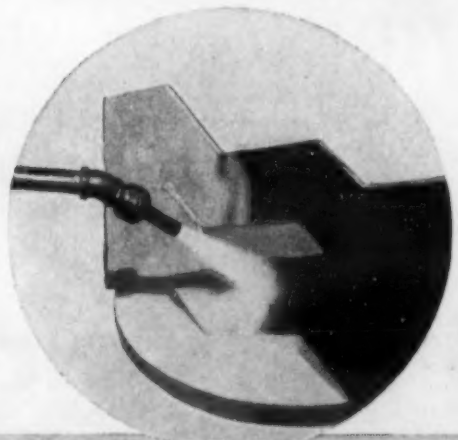

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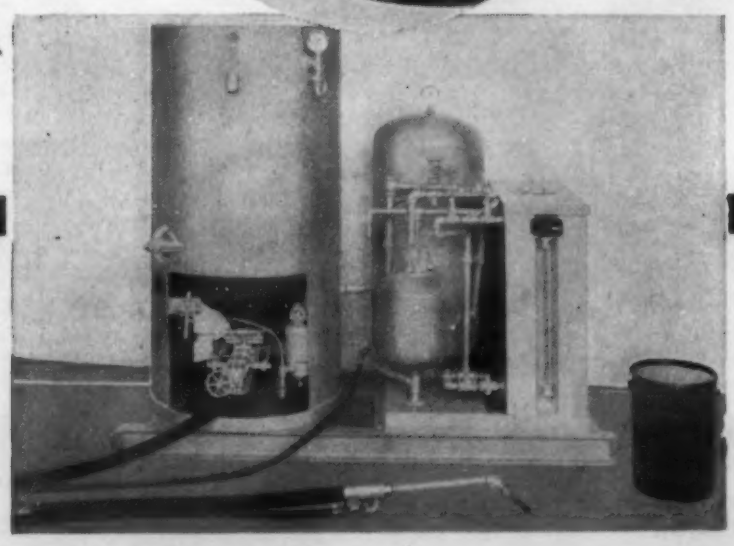

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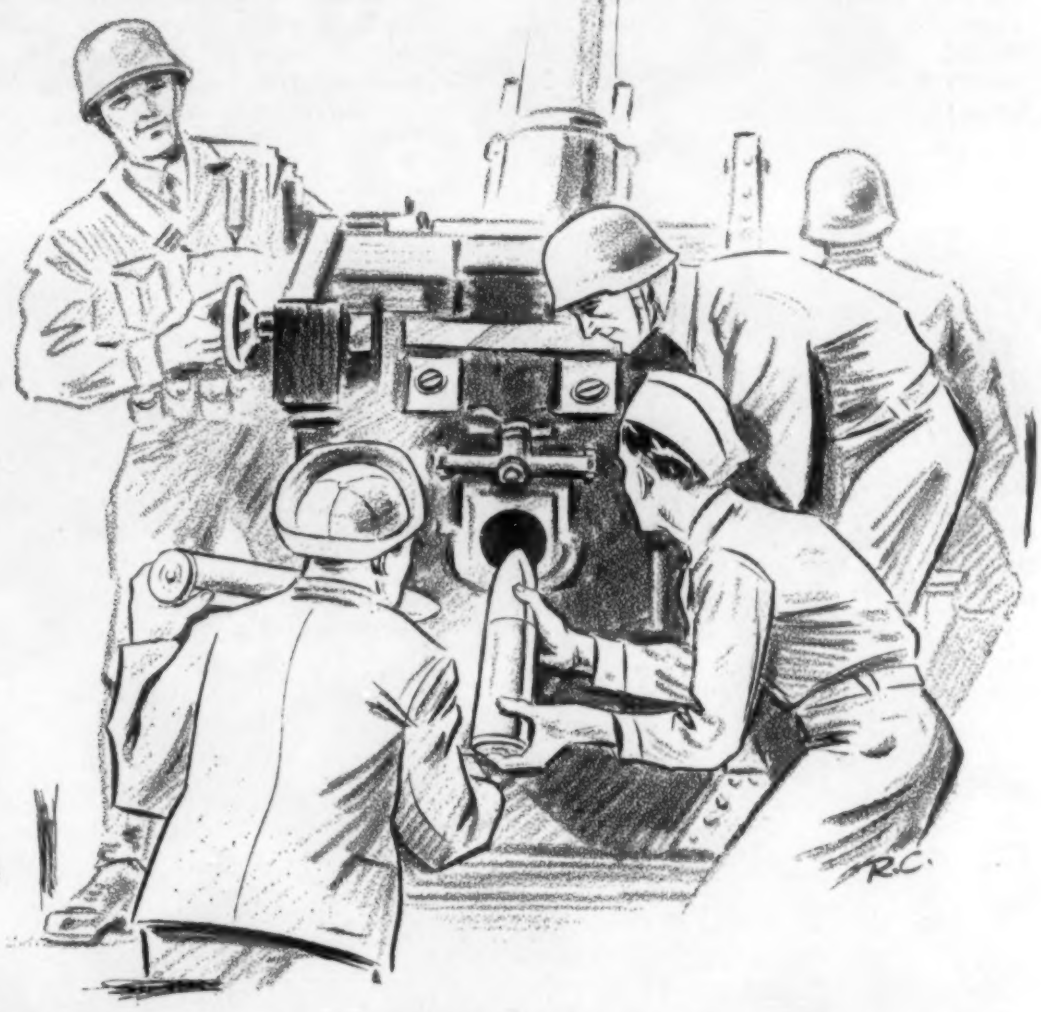

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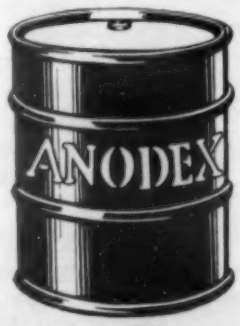

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anotner case, the surface layer was decarburized to such an extent that no oil had a fast enough cooling rate.

The links are removed from the quenching oil by a conveyor which drops them on a metal belt that carries them through an alkali wash and draw furnace. They are tempered at 545 deg. F. for 1 hr. Resulting hardness is 52-53 RC.

A conveyor carries the links from the draw furnace to a blasting machine where fine steel grit removes scale, dirt, or burrs. Then they are plated with zinc or Parkerized. Some of the plated links are subjected to strip and salt-spray tests. Solution for strip test consists of 100 gm. ammonium nitrate, 55 cc. concentrated nitric acid, and distilled water to make 1000 cc. total. Plating must withstand 18 sec. application of solution. There must be no evidence of rust after an exposure of 48 hrs. to standard salt solution. Zinc-plated links are baked for 3 hrs. at 425 deg. F. to eliminate hydrogen embrittlement.

Each link receives a 100-lb. pull test, which enables weak, brittle, and improperly dimensioned and alined links to be rejected. Another test requires that a 16-in. belt of links and cartridges withstand a twist of 180 deg. without permanent set or failure. To assure proper extraction of cartridges from the link, a steel plug made to the dimensions of a cartridge case must be extracted by a pull of not less than 15 lbs. nor more than 30 lbs.

—*Heat Treating & Forging*, Vol. 28, Aug. 1942, pp. 386-389, 395.

Low Alloy Steel in Aircraft

Condensed from "Aero Digest"

Although low alloy steels have been used in truss type structures, and stainless steel in shell type, there has been no previous application of low carbon, low alloy steels to shell type structures. After investigating various S.A.E. steels the most promising one was S.A.E. 4608 with a yield point of about 90,000 lbs. per sq. in. and an elongation of from 5 to 7 per cent.

The purpose in using low carbon steel was to eliminate the use of strategic elements. Another purpose was to utilize a common steel that could be manufactured by more than one source.

At the completion of an experimental heat of 4608 steel, the following data were obtained: Chemical composition C, 10; Mn, 0.33; P, 0.014; S, 0.023; Si, 0.160; Ni, 1.70 and Mo, 0.21 per cent. Physical properties of a longitudinal sheet were: Yield stress 39,600 lbs. per sq. in.; ultimate stress 57,000 lbs. per sq. in.; and elongation 27 per cent. For a transverse sheet the yield stress was 31.700 lbs. per sq. in.; ultimate stress 60,200 lbs. per sq. in.; and elongation 28 per cent.

Hot rolled sheets exhibited fair yield strength without too great a sacrifice in elongation. It could be bent around a minimum radius of 3t. The yield strength, however, was not up to the expected value.

The next step was to stress-relieve, by means of mild heating cycle, the cold worked material to achieve higher elongation. This material had favorable strength and elongation. It could be worked well in a hydraulic press using a Kirksite die and a rubber punch.

The substitution of steel for aluminum sheet in certain assemblies was as follows: A steel horizontal stabilizer was substituted for the aluminum alloy stabilizer. This was done to determine if a direct substitution of 4608 steel sheet for aluminum alloy sheet could be made and if it could be formed on tools designed and made for the various parts of the aluminum stabilizer. The parts formed and assembled extremely well. Vertical stabilizers were made in the same manner and also subjected to structural tests.

The outer wing flap was made of strain-relieved cold rolled type with 6 per cent elongation. The skin covering the flap differed from aluminum alloy skin in that it had beads in it for stiffening. This was done on an hydraulic press. An attempt was made to form ribs to the same shape as aluminum alloy ribs on progressive dies. Cracks developed in the return flange. A change to deep draw steel with heat treatment after forming was the remedy.

Experiments with hot rolled 0.016 steel sheet for nose ring proved that the sheet wrinkled indicating poor shrinkage. It was then decided to make a special drop hammer Kirksite die to form part in

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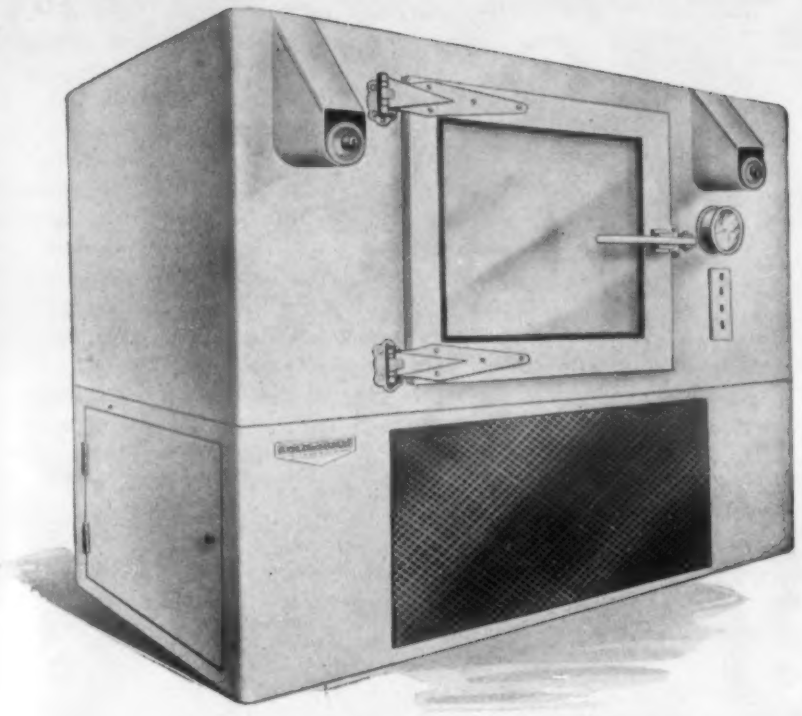

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A manufacturer of small motors was bottlenecked by lack of men and machines needed for greater production of motors on a war contract. One time-consuming operation was joining rotor bars to end rings. The brazing material being used was a sluggish alloy that not only took time to apply, but also required 33 minutes of machining afterwards to remove excess brazing deposits.

Free-flowing Phos-Copper was then specified for this brazing operation in an effort to step up production. This brazing alloy, which is fluid at 1382° F., flowed so smoothly that operators were able to place metal exactly where needed. Since only a minimum amount of Phos-Copper was required, machining operations were entirely eliminated.

Result: on one contract for 2400 motors, Phos-Copper saved 200 brazing hours, 1320 machining hours, and freed a number of lathes for other work!

Send us a memo describing your present brazing operations. Perhaps Phos-Copper can help you save time, expense and labor. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., Dept. 7-N. J-90451

Phos-Copper brazing alloy is being used on hundreds of war contracts in a multitude of applications—marine piping systems, cooling coils, bus bar structures, water heaters.

Westinghouse

eighths. This was not satisfactory but it was reworked by hand. Indications are that it will be possible to form this piece satisfactorily.

Forming removable cowling, the same as aluminum alloy seemed satisfactory, although two out of eight sheets cracked. Material was 0.016 in., 4608 hot rolled steel sheet. It is believed that the total weight increase for complete cowling per airplane will be 10 lbs. at the most.

The actual steel design of outer wing for the AT-6a training plane is under construction. General data will remain the same. Wing is designed in such manner that major items such as flaps and ailerons on the aluminum alloy wing will fit the steel wing and conversely. Gages of sheet in the main spar vary from 0.012 to 0.024. There are 12 stations approximately 15 in. apart outboard of the wing joint at which ribs are located.

The nose rib is 0.012 in. gage and was formed on an hydraulic press using a Masonite die and Cerrobend punch. Flap aileron spars and aileron fairing assemblies are 0.012 in. gage.

The relatively high strength of the stringers in relation to the yield point of the material is the result of cold working. The outer panel will be joined to the center panel by a bolted and spot-welded joint.

A study has been made to substitute steel fittings for aluminum alloy forgings. Designs already exist for such as fittings that attach the rudder to a vertical stabilizer. In general they consist of steel sheet blanked to contour and then pressed with die to a shape that permits attachment by bolting and spot-welding of the rudder to the stabilizer.

As the steel program progresses it is intended to redesign additional major assemblies. This means that entire trainer wing will be made of steel.

—Edger Schmued, *Aero Digest*, Vol. 16, July 1942, pages 191-192, 195-196, 199, 370.

A Spot Welding Kink

Condensed from "Western Machinery & Steel World"

The tendency of aluminum to alloy with the copper tip of a spotwelder necessitated cleaning after every 10-15 spots. A change from common hydrofluoric acid for cleaning metal to be spotwelded to a mixture of phosphoric and chromic acid (relative proportions not given) increased the interval between cleanings to 500 to 800 spots while as many as 3300 spots have been made without cleaning the tips. The new acid mixture also gives a cleaner, brighter surface.

Another factor aiding production is that the sheet may be left in the acid tank up to 30 mins., without injury whereas immersion in hydrofluoric acid had to be timed almost to the minute to prevent undue attack. The same soap tank and hot water rinse may be used with the new mixture as with the old HF.

—Don Holden. *Western Machinery & Steel World*, Vol. 33, July 1942, pp. 276-277

Blanking and Piercing Die

Condensed from "American Machinist"

A new type of blanking and piercing die used by Lockheed, Consolidated, Douglas and other aircraft plants, is described. Each set consists of a backing plate to which the punch is attached with flush rivets and a second backing plate to which the die is riveted. A standard precision die set is used. To the upper half a piece of aluminum is attached and in it grooves are cut into which permanent magnets are placed that hold the punch or die in place without other means of clamping.

For dural and alclad blanking, the punches are made of ¼ in. 0.5 to 0.6 per cent C plow steel. The die, which is of Kirksite A (except for thicknesses over about 1/10 in. when soft steel dies are used), is made by routing, using the punch as a rout block, or the punch is forced into the die stock sufficiently to produce a line to file to.

For blanking stainless steel or SAE 4130, the punch is made of a steel which can be flame hardened after the punch has been sawed and filed or routed to shape. The flame hardened punch is then used to cut or shear the die. Dies are made of carbon or alloy die steel with air-hardening or water-hardening characteristics which can be flame hardened. Backing plates for piercing punches are made of cold rolled steel. Backing punches for dies are made of cold or hot rolled SAE 1020.

—J. Haydock, *Am. Machinist*, Vol. 86, Aug. 6, 1942, pages 815-818.

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CONTENTS

Tin-Saving Bronzes and Brasses 954
Chromium-Manganese Stainless 960
Powder Metallurgy in Design 966
Materials and Design 968

Tin-Saving Bronzes and Brasses

Condensed from "Foundry Trade Journal"

The silicon bronzes are capable of giving reliable castings of good mechanical properties, although difficulties might be experienced in foundries having no previous experience with these alloys. B.S. War Emergency Specification gives the following limits of composition: 1.5 to 5.0 Si; 1.5 max. Mn; 5.0 Zn; 2.5 per cent Fe; remainder, copper.

Silicon Bronzes

Silicon bronzes are very fluid, producing sharp and well-defined castings from sand molds. They can also be cast by the centrifugal process and in chilled molds.

They possess approximately the following characteristics: specific gravity (cast) 8.4; weight per cu. in., 0.92 lb.; shrinkage 5/32 to 3/16 in. The average ultimate tensile strength of standard test-pieces cast in green sand is about 46,000 lbs. per sq. in., 20 per cent elongation (in 2 in.) and Brinell hardness of 90 (10 mm. ball, 500 kg.)

Silicon bronzes may be melted without difficulty in pit fires or tilting furnaces of the cake, oil- or gas-fired types. Melting should be carried out as quickly as possible, exposure to the furnace atmosphere being kept to a minimum. The melt may be kept well covered with a gasless flux, such as ordinary bottle glass, cryolite or sal-ammoniac. In cases where the liquid slag is very fluid, a sprinkling of dry silica sand may be used.

The molten metal should not be allowed to remain in the furnace too long after the casting temperature has been attained. Excessive stirring or puddling during melting should be avoided, as this is not only unnecessary but tends to disturb the protecting cover, and may cause gas pockets in castings as a result of contamination of the metal by furnace gases. The metal should be stirred with a graphite stirrer or a coated iron rod.

Care should be taken not to overheat the alloy. The characteristic of all silicon bronzes is their short freezing range, approximately 90 deg. F., and shrinkage therefore takes place at a greater speed than in the gunmetals. This necessitates special attention to the feed requirements.

The above general data on silicon bronzes refers particularly to P.M.G. and Everdur. The preferred composition of P.M.G. metal is as follows: 3.0 to 4.0 Si; 1.4 to 2.0 Fe; 1.0 max. Mn; 0.1 max. P; 1.5 to 2.5 per cent Zn; remainder copper. Typical mechanical properties are as given above for silicon bronzes.

The freezing range of P.M.G. is 1740 to 1650 deg. F. During melting a precautionary measure against oxidation is to spread charcoal over the surface of the molten metal. On all melts, a small quantity of phosphor copper, say ¼ lb., for each 100 lbs. assists deoxidation. Sal-ammoniac is a good flux to use prior to casting.

The typical chemical composition of Everdur for sand castings is as follows: 3.0 to 4.0 Si; 0.5 to 1.5 Mn; 0.0 to 1.0 Zn; 0.5 per cent impurities; remainder

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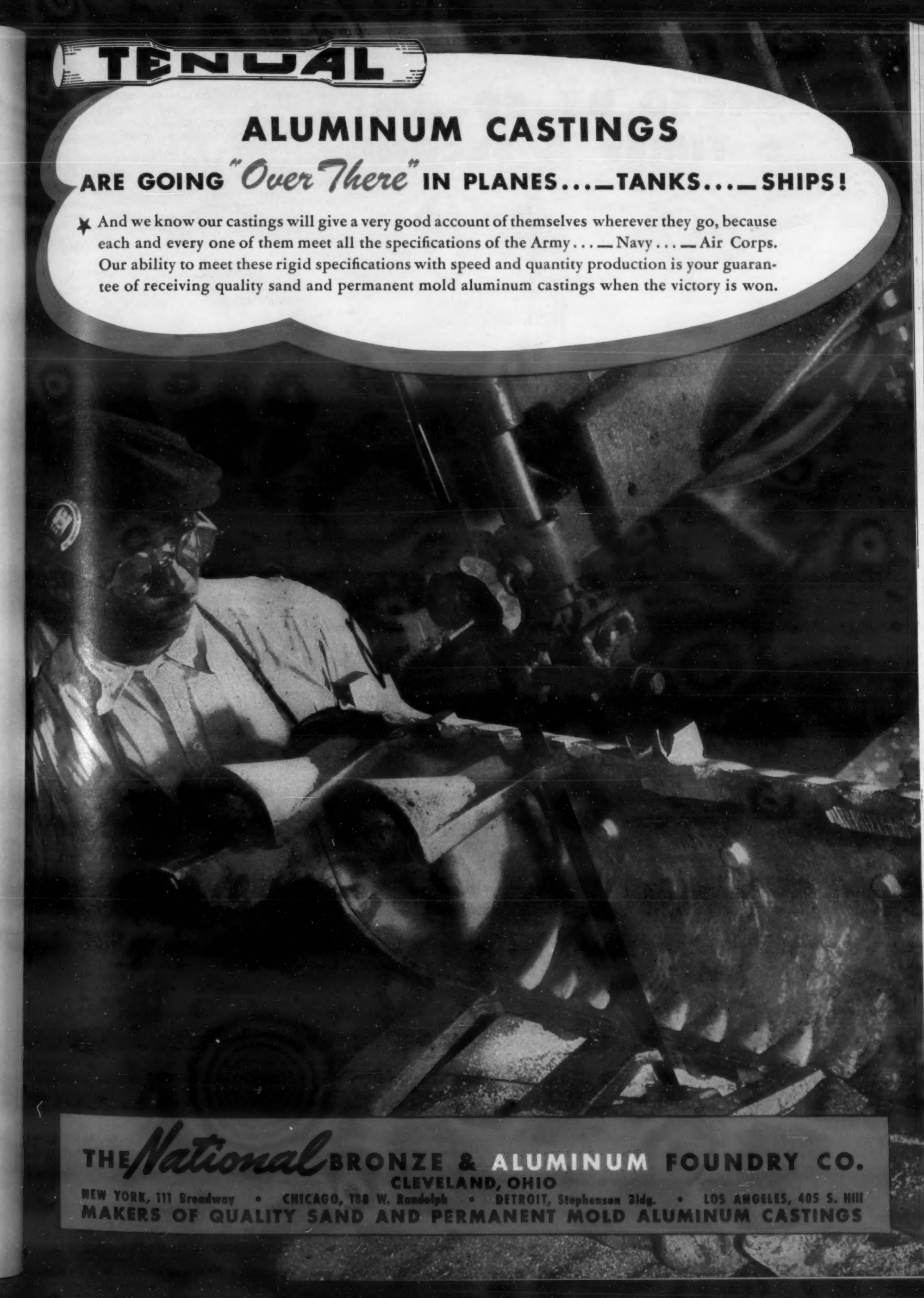

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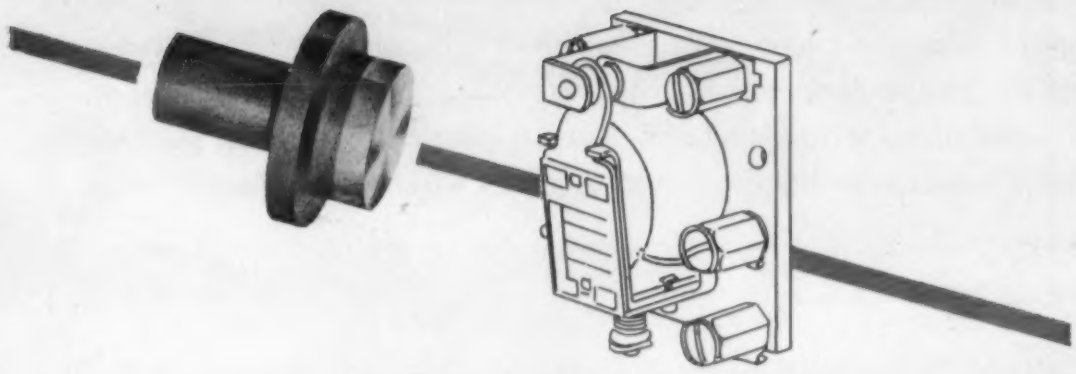

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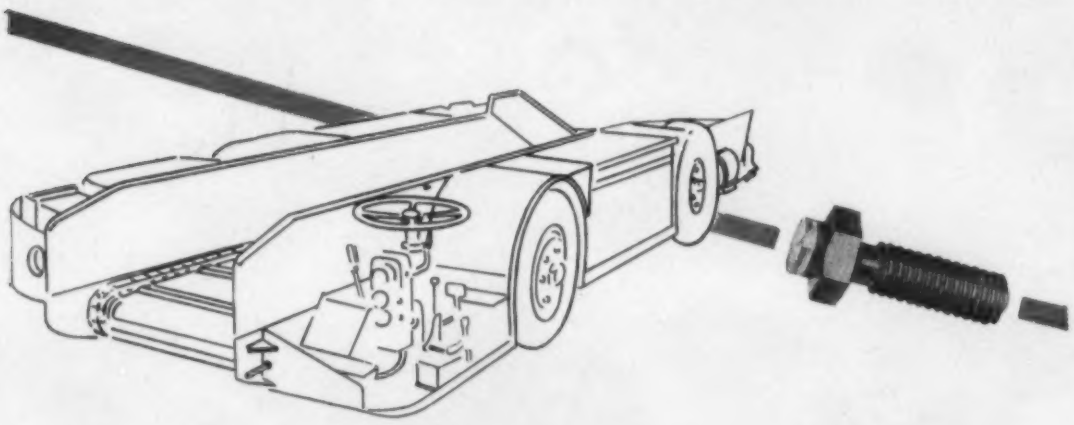

Or your product might demand maximum durability as in the automatic accelerating relays used in the Joy Manufacturing Company's mining equipment. In either case you will find Callite Contacts will help keep 'em rolling.

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copper. Ultimate tensile strength is 50,000 lbs. per sq. in.; elongation 18 to 25 per cent in 2 in.; Izod impact strength, 30 to 60 ft.-lbs.; Brinell hardness, 70 to 95.

When annealed for ½ hr. at 1290 deg. F. and slowly cooled, the ultimate tensile strength becomes 48,000 to 57,000 lbs. per sq. in., elongation 22 to 30 per cent in 2 in., Izod impact strength 40 to 55 ft.-lbs., and Brinell hardness 65 to 90. The freezing range of Everdur is 1830 to 1750 deg. F. The heaviest casting known to have been made in England in Everdur was a bowl for chemical plant weighing approximately 1100 lbs.

Gunmetals and Brasses

Some low tin content gunmetals are: (1) 88 Cu, 8 Sn, 4 per cent Zn; (2) 86 Cu, 7 Sn, 5 Zn and 2 per cent Pb; and (3) 85 Cu, 5 Sn, 5 Zn and 5 per cent Pb. L. W. Spring's work (Proc. Inst. Brit. Foundrymen, Vol. 24, 1930-1931, p. 239) shows that, while short-time tensile tests indicate that the higher tin content alloys of the 86-12-2 and 88-10-2 types are stronger than 86-7-5-2 gunmetal at elevated temperature, the latter alloy is actually more creep resistant than the former at temperatures above 500 deg. F.

It is interesting to note that the decreased tin and increased lead contents do not appear to affect creep properties appreciably. Bronze valves and fittings cast in 86-7-5-2 gunmetal can be employed up to 500 deg. F. while, if made in 85-5-5-5 material, the maximum temperature for use is limited to 400 deg. F.

Castings show a curious difference in behavior from wrought materials at low temperature, for while the strength is increased along similar lines to that which occurs in wrought materials, the ductility is always slightly less than that indicated at room temperature.

So far as the gunmetals are concerned, there is little difference in general physical properties between 88-10-2 and the other types under review.

The increased lead and zinc contents within the range of compositions covered do not appear to have much effect on the corrosion resistance of gunmetal by normal sea and fresh water. Laboratory tests show 88-10-2 to exhibit a loss in weight of 0.288 per cent after 8 weeks' immersion in sea water.

Gunmetal containing 7.0 Sn, 3.75 Zn, 3.75 per cent Pb, balance copper, showed a loss of 0.26 per cent under similar conditions. Practical observations based upon equipment in service, such as valves, tend to confirm these findings.

While an increase of temperature accelerates the corrosion of gunmetal and bronze in fresh water, using temperatures apparently reduce the rate of attack in sea water, although the degree of attack is appreciably greater than that experienced in fresh water. Care should be taken when utilizing gunmetals for handling softened boiler feed waters to keep the zinc content as low as possible.

Cast brasses of type A (70-80 per cent Cu) and type B (62-70 per cent Cu) are not recommended for use at elevated temperatures. The general remarks on me-

SMALL DIE CASTINGS ALSO SERVE

Shank shown in inset approximately ½ actual size—4,100 castings to the pound.

When the manufacturer of the tiny ZINC Alloy Die Castings shown above supplies one pound of his product to the Government, he is providing cup-eye shanks for 4,100 doctors' and nurses' uniform buttons. As shown in the inset, these die cast shanks are used in conjunction with toggle pins to form detachable button fasteners.

The die casting machine which produces these button shanks is one of a special design for turning out small parts at high speed. Such a machine is capable of production quantities as high as 320 castings per minute!

INTEGRALLY CAST RIVETS FACILITATE ASSEMBLY

One of the outstanding advantages of the die casting process is its ability to provide fastening elements as integral parts of a casting. These elements usually take the form of studs or rivets, either hollow or with hollow ends, and assembly is completed by merely riveting, staking or spinning over the ends. This makes it unnecessary to provide and to handle separate fastening elements, and effects considerable savings.

An interesting case in point is the assembly illustrated in the drawing below. Several integral studs on one ZINC Alloy Die Cast part mate with cored holes in another die casting. When the mating castings are put together, assembly is effected by simply heading over the ends of the rivets.

The cutaway shows the mating of rivets and cored holes.

ZINC ALLOY DIE CASTINGS ARE TOUGH

The ability of ZINC Alloy Die Castings to "take it" is graphically illustrated by the die cast grease seals for the steering knuckle universal joints on Army "Jeeps." If a part stands up on a "Jeep" it will stand up almost anywhere.

Here is what the manufacturer of the "Jeep" axle assemblies has to say about the die cast grease seals: "This seal has proven highly satisfactory . . . . is sturdy enough to withstand abuse from flying stones and gravel and cannot be torn off by striking sticks, stumps, small trees and so forth."

The strength of ZINC Alloy Die Castings exceeds that of most other commonly cast materials. For specific technical data on strength and other properties we suggest that you read the bulletin "Zamak Alloys for Zinc Alloy Die Castings." Just ask us for a copy—on your company letterhead.

The die cast grease seals serve in a vulnerable spot.

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chanical properties at sub-zero temperatures given for gunmetals can be applied to the cast brasses. The effect of low temperatures is not likely to cause any serious change in mechanical properties, apart from some reduction in ductility.

In general, the corrosion resistance of these alloys in sea water is not quite so good as the gunmetals, but in contact with gasoline or fuel oils containing sulphur their resistance is much greater. Care must be taken when applying the cast brasses industrially to prevent "dezincification." This is best avoided by the use of alloys containing not more than 20 per cent Zn and in addition the presence of at least 0.03 per cent of an inhibitor, either As, Sb or P.

Test results on an uninhibited naval brass are of interest. It is fairly well established that the 1 per cent Sn associated with this alloy is a retardant of "dezincification." At 150 deg. F., however, it was found that tin was without influence on the rate of the dezincification.

It is advisable to use cast brass (type A) for those castings required to resist corrosion, keeping the composition as far as possible to the 80 per cent Cu end of the specification, and to include preferably 0.03 per cent P, as an inhibitor. The presence of around 1 per cent Sn will also be of benefit in minimizing corrosion.

Foundry Practice for the Brasses

The British Standards Institutions has issued a War Emergency Specification for cast brasses. For brass of type A the composition limits are 70-80 Cu; 2 max. Sn; 1-4 Pb; 1 per cent max. Ni; remainder zinc. For brass of type B it is 70-62 Cu; 2 max. Sn; 1-4 Pb; 1 per cent max. Ni; remainder zinc.

Experience has shown that the methods of running castings made of these alloys need not differ from those adopted for bronzes unless copper content of the type B is on the low limit and aluminum on the high limit, when the characteristics of the alloys resemble those of manganese bronze.

In such cases, molding methods similar to those adopted for manganese bronze are necessary because of the high shrinkage of the alloy. Care should, however, be taken to avoid running into this difficulty. The metal runs well and gives a good casting surface.

The type of sand and mold dressing used for bronzes is quite suitable for the production of sand castings and it has not been found necessary to adopt excessive venting. It is advisable to pour both types of alloys at a lower temperature than that adopted for bronze. High casting temperatures appear to cause scabbing and poor casting surface.

Some results were obtained with test bars melted under normal foundry conditions from scrap metal and cast in green sand molds at a temperature of about 1800 deg. F. All these bars met the proposed War Emergency specification for both physical properties and chemical analysis.

Tests have been made to ascertain the effect of running sleeves and bushes of these alloys with water lubrication under a heavy load. A sleeve was mounted on

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a shaft and rotated at 1500 r.p.m., a stationary loaded bush being located around the sleeve.

Most bronzes, providing either the shaft or bushing, or both, contain 2 per cent or more of lead, will run without seizing under similar conditions of test. Bronzes that do not contain lead seize, as with the brasses. The addition of tin appears to aid the casting properties.

A test was made to determine if any difficulties would be encountered in making a medium-sized casting in type B brass using molding and gating methods commonly adopted for gunmetal. The example chosen was an air pump cover (roughly 30 in. in diam.) The rough casting looked quite satisfactory. When it was machined, however, a number of small shrinkage tears were found. Modified gating and feeding methods would eliminate these defects.

A sound section taken from the rim of the casting was examined for mechanical properties and structure. Examination showed the distribution of what is apparently the delta constituent arising through the presence of tin. This constituent promotes brittleness, and it is interesting to note that in this case a tin content of 1.2 per cent has reduced ductility as indicated by elongation tests to 9.0 per cent. It might be assumed that when the copper content in type B brass is on the low side of the compositional range a tin content of 1.0 per cent should not be exceeded.

—*Foundry Trade J.*, Vol. 67, June 25, 1942, pp. 205-208, 210; July 2, 1942, pp. 221-230; July 9, 1942, pp. 247-251.

Chromium-Manganese Stainless

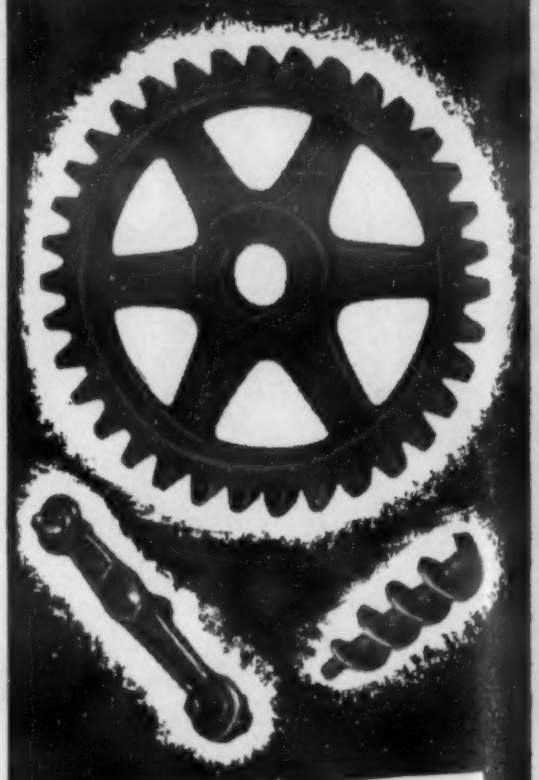
A Composite

The critical-metals situation is now such that any substitution of manganese for nickel that is feasible mechanically, is highly desirable strategically. Considerable interest attaches therefore to recent work on the properties of high-manganese stainless steels, in which all or part of the nickel normally present in 18-8 or 17-7 stainless is replaced by manganese. A series of publications by metallurgical engineers of the Electro Metallurgical Co., with special attention to the properties of cold-worked high-manganese stainless, are worthy of review.

Comparison with Straight Chromium-Nickel

In one article R. Franks and W. O. Binder *(J. Aeronautical Sci.*, Sept. 1942, pp. 419-438) report on the tension and compression stress-strain characteristics of cold rolled austenitic chromium-nickel and chromium-manganese-nickel stainless steels. Procedure and results on 17-7 and 18-8 already given by Bandel *(Metals and Alloys*, Vol. 15, Jan. 1942, pp. 174-178) and Franks & Binder *(Proc. A.S.T.M.*, Vol. 41, 1941, pp. 629-645) have been supplemented by more complete graphic presentation of these data as well as by new data on a steel with 0.12 C, 17.5 Cr, 4.3 Ni and 5.4 per cent Mn, also on 0.035 in. strip.

Scientifically Controlled Alloy Analyses



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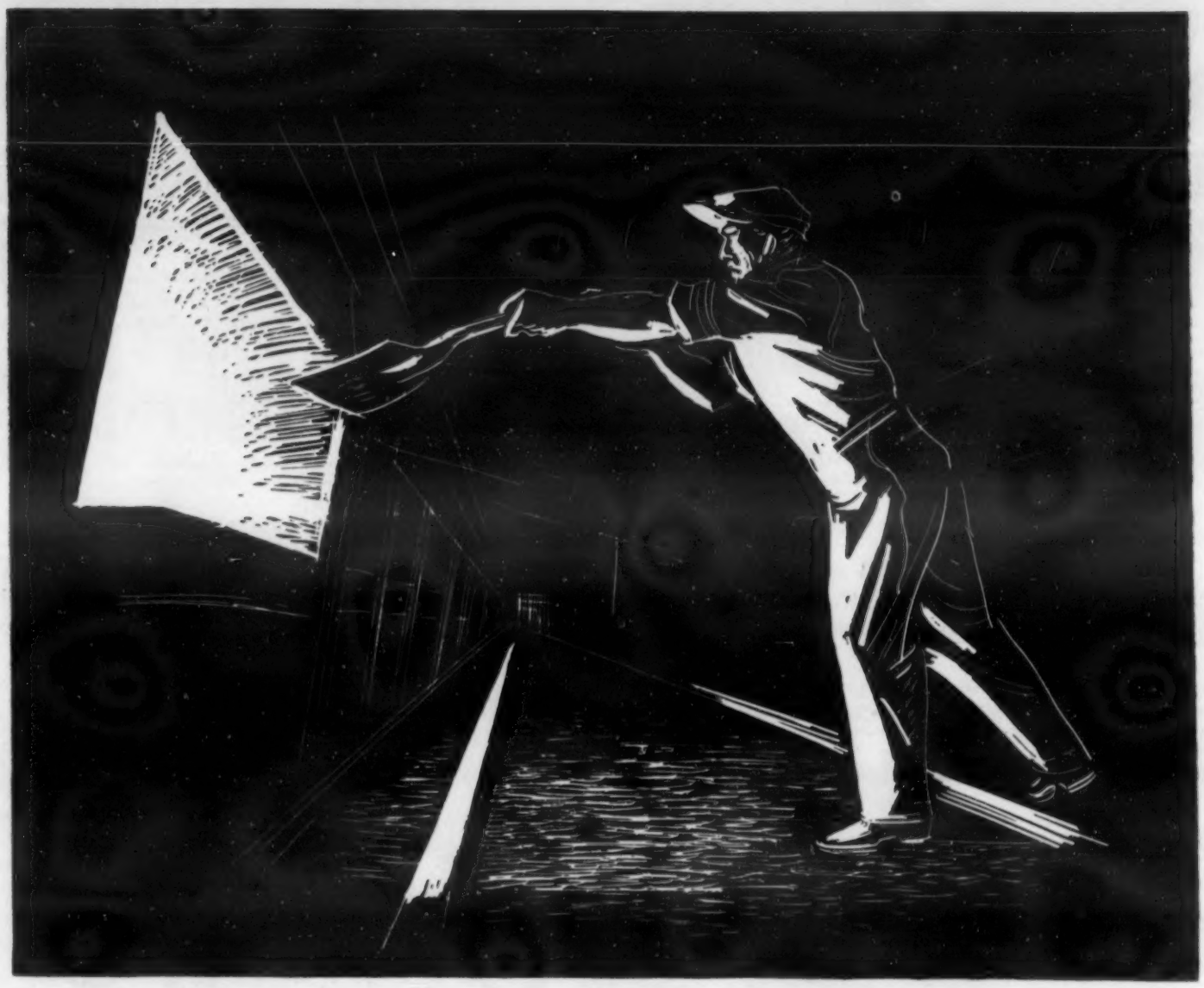

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TABLE I. LONGITUDINAL PROPERTIES

Composition	tensile strength psi	0.2% offset yield strength psi	prop. limit psi	elong. % in 2 in.	initial tangent modulus of elas. million psi
17.5% Cr—4.3% Ni—5.4% Mn	138,500	40,700	25,500	65	29
17.1% Cr—7.2% Ni	117,800	33,000	14,000	68	29
18.4% Cr—8.8% Ni	94,500	36,000	16,300	61	29

TABLE II. LONGITUDINAL PROPERTIES, 35% COLD REDUCTION

Composition	tensile strength psi	0.2% offset yield strength psi	prop. limit psi	elong. % in 2 in.	initial tangent modulus of elast. million psi
17.5% Cr—4.3% Ni—5.4% Mn	213,000	157,000	33,000	19	28
17.1% Cr—7.2% Ni	196,000	164,000	50,000	15	26
18.4% Cr—8.8% Ni	155,300	131,000	53,000	15	26

TABLE III. LONGITUDINAL PROPERTIES, 35% COLD REDUCTION, STRESS RELIEVED

Composition	tensile strength psi	0.2% offset yield strength psi	prop. limit psi	elong. % in 2 in.	initial tangent modulus of elast. million psi
17.5% Cr—4.3% Ni—5.4% Mn	203,500	182,000	54,000	18	28
17.1% Cr—7.2% Ni	198,000	180,000	53,000	14	27
18.4% Cr—8.8% Ni	173,400	155,000	60,000	11	27

TABLE IV. COMPRESSIVE PROPERTIES, 35% COLD REDUCTION, STRESS RELIEVED

Stress Direction	buckling stress, psi	0.2% offset yield strength psi	prop. limit psi	initial tangent modulus, million psi
longitudinal	202,000	168,000	57,400	27
transverse	228,600	207,000	95,000	29

TABLE V. LONGITUDINAL PROPERTIES

Composition, %					tensile strength psi	0.2% offset yield strength psi	prop. limit psi	elong. % in 2 in.	initial tangent modulus of elast. million psi
C	Mn	Ni	Cu	Cr					
0.10	16.5	..	1.1	..	120,000	29,000	16,000	45	28
0.10	16.3	1.1	1.1	..	132,000	33,000	17,000	55	28
0.20	15.6	1.0	1.1	3.2	132,600	31,000	20,000	65	28
0.14	15.8	..	..	12.2	142,800	30,000	24,000	67	28

TABLE VI. LONGITUDINAL PROPERTIES, 35% COLD REDUCTION

Composition, %					tensile strength psi	0.2% offset yield strength psi	prop. limit psi	elong. % in 2 in.	initial tangent modulus of elast. million psi
C	Mn	Ni	Cu	Cr					
0.10	16.5	..	1.1	..	195,500	139,000	58,000	18	28
0.10	16.3	1.1	1.1	..	184,500	125,000	34,000	17	27
0.20	15.6	1.0	1.1	3.2	190,600	133,000	45,000	8	26
0.14	15.8	..	..	12.2	215,000	151,000	66,000	13	28

TABLE VII. LONGITUDINAL PROPERTIES, 35% COLD REDUCTION, STRESS RELIEVED

Composition, %					tensile strength psi	0.2% offset yield strength psi	prop. limit, psi	elong. % in 2 in.	initial tangent modulus of elast., million psi
C	Mn	Ni	Cu	Cr					
0.10	16.5	..	1.1	..	187,000	146,000	74,000	16	29
0.10	16.3	1.1	1.1	..	181,800	139,000	41,000	17	28
0.20	15.6	1.0	1.1	3.2	190,500	146,000	82,000	16	26
0.14	15.8	..	..	12.2	214,000	157,000	81,000	20	28

TABLE VIII. COMPRESSIVE PROPERTIES, 35% COLD REDUCTION, STRESS RELIEVED

Composition, %					direction	buckling stress, psi	0.2% offset yield strength, psi	prop. limit	initial tangent modulus of elast., million psi
C	Mn	Ni	Cu	Cr					
0.10	16.5	..	1.1	..	long.	195,500	150,000	84,000	29
					trans.	219,500	184,000	110,000	29
0.10	16.3	1.1	1.1	..	long.	185,600	143,000	73,000	27
					trans.	215,500	190,000	113,000	28
0.20	15.6	1.0	1.1	3.2	long .	182,800	140,000	83,000	27
					trans.	216,000	185,000	96,000	29
0.14	15.8	..	..	12.2*	long.	175,500	131,000	60,000	28
					transv.	207,500	176,000	93,400	29

* 33% cold reduction.

As annealed this steel has higher tensile strength (in longitudinal tests) than either 17-7 or 18-8 strip (see Table I).

After equivalent amounts of cold work, the chrome-manganese-nickel has higher tensile strength, yield strength, elongation and tangent modulus, but a lower proportional limit (see Table II).

Stress relieving (24 hr. at 392-437 deg. F.) increases the yield strength and proportional limit, so that the chrome-manganese nickel and 17-7 are about equal except for the higher ductility and modulus of the chromium-manganese-nickel (see Table III).

After reducing 35 per cent and stress relieving, the chromium-manganese-nickel shows little directional difference in tension but, as with 17-7 and 18-8, the compressive values transverse to the direction of rolling are considerably better than longitudinal properties (see Table IV).

As far as mechanical properties are concerned, the cold rolled chromium-nickel-manganese steel is superior to 18-8 and at least equal to 17-7. The chromium-

Advertisement NOVEMBER, 1942

COPPER ALLOY BULLETIN

REPORTING NEWS AND TECHNICAL DEVELOPMENTS OF COPPER AND COPPER-BASE ALLOYS

Prepared Each Month by the Bridgeport Brass Co. "Bridgeport" *Headquarters for BRASS, BRONZE and COPPER*

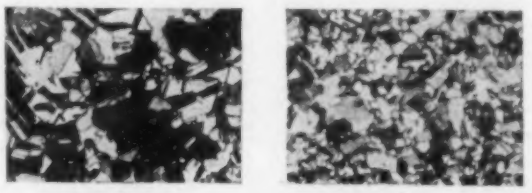
Unusual Properties of 70-30 Brass Make It Ideal for Cartridge Cases

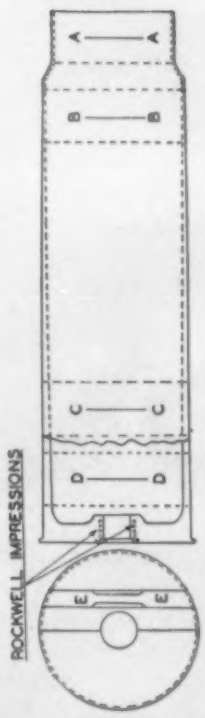
Can Be Readily Annealed or Cold Worked to Meet The Wide Range of Physical Properties Required

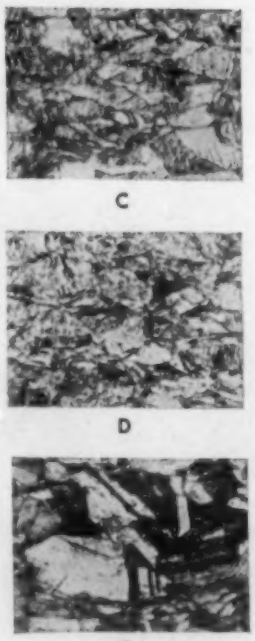
Because the properties of 70-30 Brass can easily be modified by cold working or annealing to achieve various degrees of strength, hardness and elasticity, this alloy is ideal for cartridge cases, where a wide range of physical properties must be met.

The purpose of a cartridge case is to provide a means of igniting a charge and preventing the escape of gases resulting from the explosive charge. The metal around the primer hole must be sufficiently hard and elastic to make sure that there is no loosening of the primer and no case leakage in the primer hole due to the pressure in firing. The wall of the case must be elastic enough to expand under pressure and make a tight seal against the breech wall of the gun. Unless it is properly supported by the breech wall, the pressure developed by the propellant charge is sufficient to burst any case. The low modulus of elasticity of 70-30 Brass permits the quick expansion of the case to take place without permanent set. When the pressure drops, the case returns to its normal size. These requirements are necessary to produce the gas seal and the easy removal of the case after firing.

The wide range of properties that must be met in making a cartridge case are illustrated in the accompanying drawing and photographs from the paper on "Physical Properties of Brass Cartridge Cases" by R. S. Pratt, Metallurgist for Bridgeport Brass Company, which was presented before the American Society of Mechanical Engineers on December 1, 1941. Section E in the drawing, taken from the base, has a tensile strength of about 52,000 lbs. per square inch. Its microstructure shows the effects of some cold working resulting from the heading operation. Section D, at the base of the shell, has a tensile strength of 101,900 lbs. per square inch and shows a characteristic severely cold worked structure produced from the last drawing operation. Section C has a tensile strength of 96,800 lbs. per square inch and is also severely cold worked. Section B, below the mouth of the shell, has a tensile strength of 53,950 lbs. per square inch and its structure shows a fine grain resulting from the anneal prior to tapering. Some cold working of the structure has resulted from the tapering. Section A, taken from the mouth of the shell, is completely recrystallized and has a tensile strength of 52,000 lbs. per square inch.







All samples MAG. 75X

The ability of 70-30 Brass to meet this wide range of requirements will be seen from the rolling and annealing graphs on this page. In Figure 1, for example, it will be noticed that the tensile strength of 70-30 Brass varies from about 48,000 lbs. per square inch in the soft condition to above 110,000 lbs. per square inch at 80% reduction by cold rolling. In other words, it is possible to more than double the strength of annealed brass by cold working. How the degree of softness of 70-30 Brass can be controlled by varying the annealing temperature is shown in Figure 2. When the alloy is annealed at 350° C., for example, its tensile strength is approximately 58,000 lbs. per square inch, while at 650° C., the tensile strength drops to about 44,000 lbs. per square inch.

It is to be noted that the finished case had been given a relief heat treatment to free it from dangerous internal stresses resulting from previous cold working operation. The relief of these internal stresses prevents the danger of season cracking so prevalent in World War I. This heat treatment is carried out at temperatures ranging from 250° to 275° C., and must be carefully controlled to prevent overheating of the case, with a consequent softening and loss of tensile strength. Such a low temperature heat treatment is difficult to control in an ordinary furnace and for this reason special furnaces of the convection or salt bath type should always be used by the fabricator for relief annealing in order to obtain successful results.

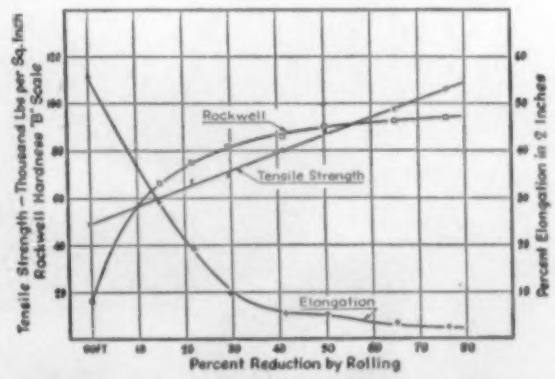


Fig. 1, Rolling curves, sheet Cartridge Brass annealed at 0.100 in. gage—grain size 0.058 mm.

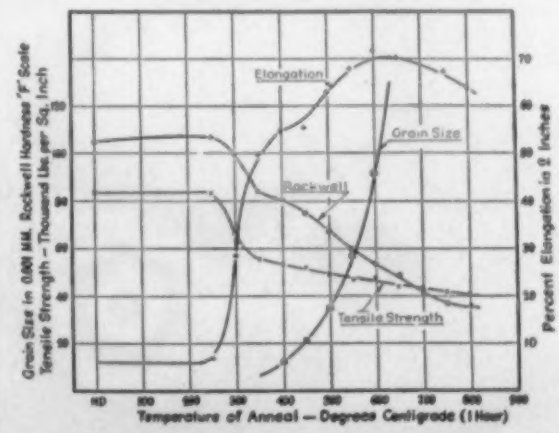

Grain Size in 0.001 in.
Rockwell Hardness "F" Scale
Tensile Strength – Thousand Lbs per Sq. Inch
Percent Elongation in 2 Inches
Elongation
Grain Size
Rockwell
Tensile Strength
Temperature of Anneal – Degrees Centigrade (1 Hour)

Fig. 2, Annealing curves, sheet Cartridge Brass rolled 50 per cent hard to 0.050 in. and annealed at indicated temperatures.

TYPICAL SPECIFICATIONS FOR CARTRIDGE CASES 75 MM—M18		ACTUAL SPECIFICATIONS OF SAMPLES SHOWN	
POSITION	MIN. TENSILE STRENGTH LBS./SQ. IN.	TENSILE STRENGTH LBS./SQ. IN.	ELONGATION
A	45,000	52,000	51.6% in 2 in.
B	45,000	53,950	48.5% in 2 in.
C	65,000	96,800	7.0% in 2 in.
D	65,000	101,900	5.0% in 2 in.
E	60,000	62,100	30.0% in 1 in.

COPPER ALLOY BULLETIN

CAUSES OF CORROSION

ELECTROCHEMICAL THEORY OF CORROSION

This is the first of a series of articles by C. L. Bulow, research chemist at Bridgeport Brass Company, discussing some of the fundamentals of corrosion as applied to numerous common failures occurring in various types of services. An extended discussion of the various factors influencing corrosion rates will show how complex the problem is, and on the other hand, may suggest the solution to a troublesome corrosion problem. It is hoped that readers will find this information helpful.

Since 1900 a steadily increasing amount of research work has been applied to the study of the fundamentals of corrosion. This work has shown that the basic phenomena are the same for all metals and alloys.

These fundamentals are the same as those which are used to describe all chemical reactions, namely the attraction and repulsion between electrically charged particles (atoms) such as in electroplating, storage batteries and dry cells. All metals when placed in water, or a water solution of an acid, base or salt, which can conduct electricity, have a tendency to dissolve at the surface in contact with the water as electrically charged atoms called "ions." Each atom of metal (M) in dissolving forms a positively charged metal ion (M^+) and gives up one or more negatively charged electrons (e). This reaction in the language of the chemist becomes:

(1) $M \rightarrow M^+ + e$

The electrons which are released immediately react with an equivalent number of positively charged atoms of hydrogen (H^+) which form an invisible layer of neutral hydrogen atoms and thus replaces the dissolved layer of metal atoms:

(2) $e + H^+ \rightarrow H$

These hydrogen ions were formed by a slight dissociation or break up of water into positively charged hydrogen ions (H^+) and negatively charged hydroxyl ions (OH^-):

(3) $H_2O \rightarrow H^+ + OH^-$

The negatively charged hydroxyl ion is attracted to the positively charged metal ion to form the metal hydroxide:

(4) $OH^- + M^+ \rightarrow MOH$

which also deposits on the metal surface.

The sum of these four reactions is expressed in the following equation:

(5) $M + H_2O \rightarrow MOH + H$

If the metal is left in the water solution long enough the metallic hydroxide film becomes visible (for example rust). This in-

(Continued in column 2)

Bronze Welding Advised For Rebuilding Pistons

Because it is easily applied with a minimum of heating and easily machined, bronze welding rod is particularly suitable for the rebuilding of worn pistons. The usual temperature ranges found in industrial reciprocating equipment generally range from 300 to 400 degrees F.—well below the point at which the bronze weld metal loses strength. Furthermore, less preheating is necessary which reduces the possibility of warping.

Good results in this type of work are being obtained with Bridgeport Brass Bronze Welding Rods because of their purity, reliability and uniformity. They may be used on all cast iron, steel, and bronze work. For further information, write today for a free copy of Bridgeport's new manual on bronze welding alloys.

CAUSES OF CORROSION

(*Continued from column 1*)

tangible displacement reaction (5) is similar to the familiar displacement reaction which occurs when a piece of iron immersed in copper sulfate becomes coated with a thin visible red layer of copper instead of the invisible layer of hydrogen:

(6) Metallic Iron + Copper Sulfate → Iron Sulfate + Metallic Copper

$$Fe + CuSO_4 \rightarrow FeSO_4 + Cu$$

When the more active metals, such as lithium, sodium and potassium are placed in water the hydrogen appears as bubbles of gas rapidly rising from the surface of the metal, instead of a film of hydrogen according to the reaction:

(7) 2 Hydrogen Atoms → Molecule of Hydrogen Gas

$$2H \rightarrow H_2 \uparrow$$

The less active metals, such as iron, nickel and copper generally produce a thin layer of hydrogen on the metal surface and seldom produce bubbles of hydrogen gas. The formation of this hydrogen film greatly retards the corrosion process and if it is not removed no chemical change or corrosion is apparent. However, if oxygen is supplied, the oxygen will react with the hydrogen to produce water:

(8) 2 Hydrogen Atoms + Oxygen Atom → 1 Water Molecule

$$2H + O \rightarrow HOH$$

The removal of the corrosion product hydrogen by reaction (8) permits the reaction (5) to continue until the oxygen, water or metal is completely consumed.

(*The discussion of these reactions will be continued in this column next month*)

NEW DEVELOPMENTS

A liquid germicide for use in cutting oils has been developed to protect the worker. Application of 4 oz. in 55 gal. of cutting oil makes a 1 to 5,000 solution of p-tertiary amyl phenol that is said to destroy germs but not be irritating, corrosive or poisonous. **(No. 380)**

A tool stand to hold micrometers or snap gages without damage to the finish of the frame has been announced. It is said to permit faster work in checking parts because the operator, instead of holding the gage in one hand, has both hands free to handle the work. **(No. 381)**

A polishing disc lubricant is available which is said to increase disc lift from 25 to 33 per cent when applied sparingly to abrasive discs used on flexible shafts or on disc grinders. It is further claimed that the metal is not burned or discolored by overheating, cutting qualities of the abrasives are not retarded, and a finer, softer and more satin-like finish is obtained. **(No. 382)**

Inspection magnifiers have been developed for use on close inspection, parts assembly and precision machining operations. In three of the models offered, the head is balanced to bracket to permit use over a wide bench area. One of these models has a five-inch lens, one a four-inch lens and one has both of these lenses adjustable to focus. A fourth model, designed for precision machining applications, has a five-inch lens, is fitted with safety lens and is equipped with universal brackets. **(No. 383)**

A new cutting oil has been put on the market which is claimed to have greatly increased penetration, cooling power, film strength and "wetting" ability. Used alone or in combination with other oils, the maker says tools bite deeper and cut faster without creating excessive heat. **(No. 384)**

An angle type drill has been built especially for high speed drilling in difficult-to-reach, relatively inaccessible spots. It is said to remain cool even after prolonged operation. The overall length of this tool is 5¾ inches. The nose spindle is fitted with 10-32 thread and is available only in a 90-degree model. **(No. 385)**

A paint has been developed which is said to combine the hiding power and economy of water-type paints with the washability, durability and performance of oil-type coatings. The maker says it primes, seals, and finishes on any interior surface in one coat. It may be applied to plaster, concrete, brick, wallboard, wood, wallpaper and metal surfaces. The product is further said to be self-leveling, to set within two hours, to dry within 12 hours and to provide a dead-flat finish. **(No. 386)**

A precision plumb-bob is offered which features the use of phonograph needles to assure a true and constantly sharp point at practically no replacement cost. The needle is held by a watchmaker's pin chuck. **(No. 387)**

This column lists items manufactured or developed by many different sources. Further information on any of them may be obtained by writing Bridgeport Brass Company which will gladly refer readers to the manufacturer or other source.

PRODUCTS OF THE BRIDGEPORT BRASS COMPANY

Executive Offices: BRIDGEPORT, CONN.—Branch Offices and Warehouses in Principal Cities

SHEETS, ROLLS, STRIPS—*Brass, bronze, copper, Duronze,* for stamping, deep drawing, forming and spinning.

CONDENSER, HEAT EXCHANGER, SUGAR TUBES—For steam surface condensers, heat exchangers, oil refineries, and process industries.

PHONO-ELECTRIC* ALLOYS—High-strength bronze trolley, messenger wire and cable.

WELDING ROD—For repairing cast iron and steel, fabricating silicon bronze tanks.

LEDRITE* ROD—For making automatic screw machine products.

"Bridgeport" BRASS

Established 1865

COPPER WATER TUBE—For plumbing, heating, underground piping.

DURONZE ALLOYS—High-strength silicon bronzes for corrosion-resistant connectors, marine hardware; *hot rolled sheets* for tanks, boilers, heaters, flues, ducts, flashings.

BRASS, BRONZE, DURONZE WIRE—For cap and machine screws, wood screws, rivets, bolts, nuts.

FABRICATING SERVICE DEPT.—Engineering staff, special equipment for making parts or complete items.

BRASS AND COPPER PIPE—"Plumrite"* for plumbing, underground and industrial services.

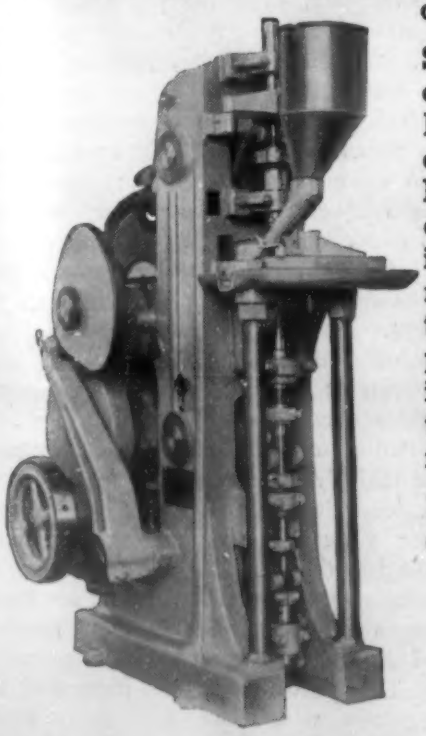
*Trade-name.

Note: Bridgeport products are supplied in accordance with existing priority regulations.

BRIDGEPORT BRASS

Completely Formed, Ready for Sintering, in a Single, Rapid Operation

Many parts for war production are made more efficiently *and faster*, from powdered metals . . . small ordnance components, porous bearings, iron gears, motor and generator brushes, hard carbide tool bits, contact points, others.



Stokes Automatic Presses are widely applicable, produce intricate as well as simple parts. Rates are up to hundreds per minute, varying with the size, material and character of the piece. On small pieces, such as chemical catalysts, production of thousands per minute is obtained.

In manufacture by powder metallurgy density is readily controlled, to obtain high porosity, as required in porous bearings, or the extreme density necessary in hard carbide tools. Parts are formed in a single operation, ready for sintering, often require no repressing or other finishing operations. Tolerances are maintained within close limits and parts are remarkably uniform in physical characteristics.

Stokes Presses are the result of 25 years of research and development work in powder metallurgy. They are available in standard and "special" models, with up to 8" die-fill and to make parts up to 4" dia.

Write for new 48-page, illustrated catalog, with machine specifications, engineering data, information on selection of equipment, etc.

Our engineering and laboratory facilities are available and consultation on specific problems is invited.

F. J. STOKES MACHINE COMPANY

5972 Tabor Road Olney P. O. Philadelphia, Pa.

Representatives in New York, Chicago, Cincinnati, St. Louis, Cleveland, Detroit
Pacific Coast Representative: L. H. Butcher Company, Inc.

F.J.Stokes

AUTOMATIC TABLETTING EQUIPMENT

FJS Est. 1895

manganese-nickel steel is also stated to have satisfactory resistance to staining under atmospheric conditions.

A logical continuation of this work is found in the article by R. Franks, W. O. Binder, and C. M. Brown on high-manganese austenitic steels *(Iron Age,* Vol. 150, Oct. 1, 1942, pp. 51-57). Three classes are discussed, all with about 16 Mn, one with up to 2 Ni and up to 1 per cent Cu; one with the same nickel and copper and about 3 per cent Cr; and one with 12 per cent Cr.

All tests were made on 0.035 in. strip. The as-annealed properties indicate that the chromium modifications have a higher strength but also a higher elongation (see Table V).

Cold work will increase the tensile strength of these steels as shown by the following figures for 35 per cent cold reduction (see Table VI).

A 24-hr. stress relief at 392 deg. F. has the same beneficial effect on these properties (especially proportional limit) as on the chromium-nickel austenitic steels (see Table VII).

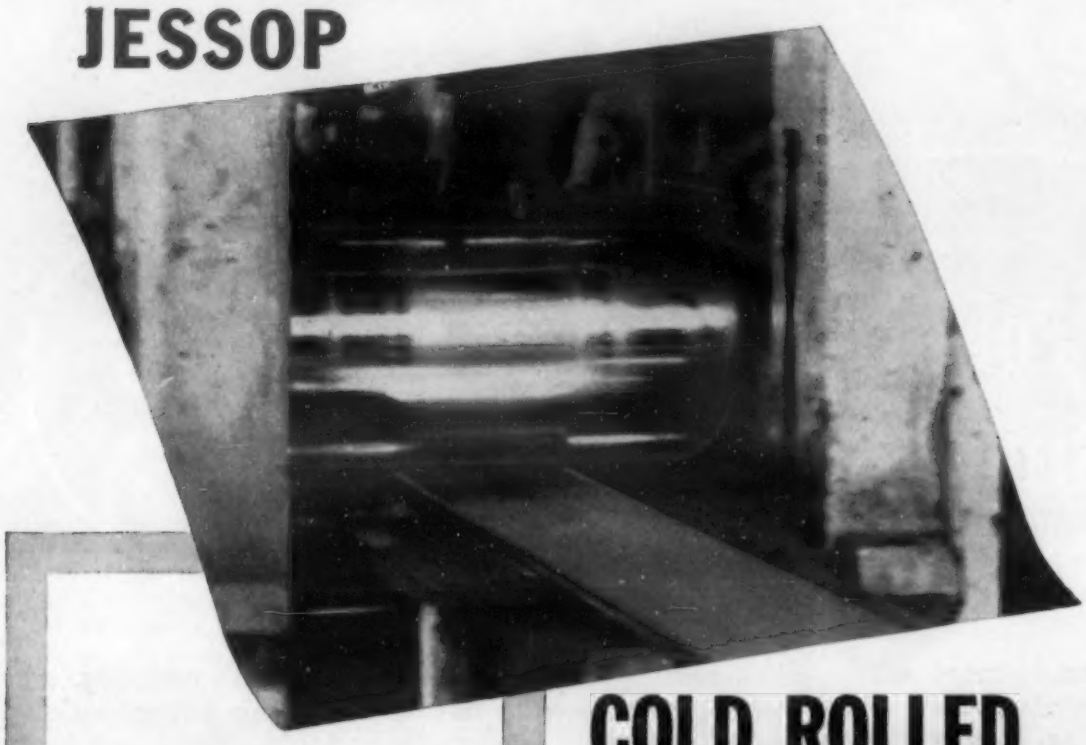
Directional properties are most evident in compressive properties after cold work (see Table VIII).

These steels therefore are comparable in mechanical properties to the 17-7 and 18-8 steels. Under atmospheric conditions, the chromium-free steels (with or without nickel and copper) will rust, while the 3 per cent Cr addition greatly retards progressive rusting, and the 12 per cent Cr addition gives a high degree of resistance to rusting. These steels can be machined and sheared without difficulty if the carbon is not too high.

Steels of the analyses given above will take 180 deg. bends in both directions as-annealed ($r = t$), and as-cold-reduced 35 per cent ($r = 3t$). Bending properties are not affected by temperatures down to —85 deg. F. in the case of all except the manganese-copper steel, where the angle of bend at failure is decreased to 65 deg. at this temperature.

The manganese steels could be spot-welded under conditions used for cold-rolled 18-8 and such welds exceeded the minimum 1500-lb. per spot required for stainless of this gage. These steels appear to have extremely promising properties for aircraft construction and other light weight structures.

JESSOP



Aircraft Sheets and Strip
Alloy Spring Steel
Bell Crank Steel
Chain Steel
Chrome Vanadium Spring Steel
Clip Steel
Clipper Blade Steel
Clock Spring Steel
Creasing Rule
Cutlery Steel
Diaphragm Steel
Ejector Blade Steel
Flexible File Steel
Knife Blade Steel
Link Steel
Manicure File Steel
Metal Band Saw Steel
Paragon Wire
Penn Steel
Plane Blade Steel
Rule Steel (Rulers and Scales)
Scoring Rule Steel
Skate Steel
Spring Steel
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Surgisteel
Tone Bar Steel
Tool Steels
Wood Band Saw Steels

JESSOP STEEL CO. FINE JESSOP STEELS WASHINGTON, PA.

COLD ROLLED Steels

Jessop produces a wide analysis range in Cold Rolled Untempered products commercially available in high carbon steels, Special Alloys, Stainless and Tool Steels. Jessop is able to produce under accurate metallurgical control Hard, Half-Hard, Quarter-Hard or Fully Spherodized Annealed conditions —whichever is best suited for your exacting requirements. This wide range of tempers is controlled by varying degrees of cold work or annealing.

SIZE RANGE—(Furnished in coils or cut lengths, square sheared or round mill edges)

Width	Thickness
¼" to 2"	.009/.125"
2" to 4"	.020/.125"
4" to 5½"	.020/.125"
*6" to 28" max.	.025/.250"

*Cut lengths only—6 to 8 ft. maximum

Write today regarding your Cold Rolled Untempered Steel problems. We will give your inquiries prompt consideration and our very best attention.

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JESSOP STEELS
for America and her Allies

Powder Metallurgy in Design

Condensed from "Machinery"

Powder metallurgy results in savings in time, materials, labor and machines. The powder is formed in a die to a "briquette." The die and punch must be accurately designed to compensate for the subsequent size change of the briquette in sintering.

This forming is done in a press under a pressure of 20,000 to 100,000 lbs. per sq. in. The larger presses must move at a very slow rate, since the powder will not flow around corners and since time must be allowed for the metal particles to become interlocked and the air to escape. Also each press cycle has a series of movements rather than the straight up-and-down motion of an ordinary punch press.

The briquette is subsequently sintered in a furnace with suitable atmospheric control. All sintered parts are porous, but the porosity can be varied from 5 to 50 per cent. This porosity has accounted for the most widespread application of sintered parts at the present, namely, porous oil-retaining bearings. These bearings are made from several compositions: Bronze (made directly from copper and tin powders), lead, iron, etc.

After sintering, the bearings are impregnated with oil. This impregnation is best carried out by evacuating the air from the pores by vacuum and then forcing the oil into the same cavities under pressure. The porosity is also important in Porex filters which are used to remove undesirable materials from fluids *(i.e.* in high speed Diesel engines), to separate two fluids, and to serve as a diffusing medium to bring fluids and gases into intimate contact.

A recent application of powder metallurgy is in the production of Babbitted main and connecting rod bearings. Copper and nickel powders are sintered onto

On Every Battlefront—

You'll find N-A-X 9100 Series of Alloy Steels

There is hardly a theater of war today where N-A-X 9100 Series is not at the beck and call of our armed forces. If you looked for it, you wouldn't find it. It's there, though, in tanks, bombs, trucks, anti-aircraft and other types of guns and armament. And there it will stay until Victory is won.

N-A-X 9100 Series is an outstanding achievement of Great Lakes engineers and metallurgists. (*It is basically an alloy steel, with all strategic elements carefully balanced and held to an absolute minimum.*) It is being supplied in two general grades, with and without molybdenum, all other components of the analysis being held constant.

GREAT LAKES STEEL CORPORATION
Detroit, Michigan
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NATIONAL STEEL

Division of
NATIONAL STEEL CORPORATION
Executive Offices · Pittsburgh, Pa.

steel strip so as to give a thin but strong, porous framework. The strip is then heated, the air withdrawn by vacuum from the cavities in the matrix, and the matrix impregnated with the Babbitt metal. The strip is then automatically cut to required size, formed, and machined to size. Road tests have shown that the new bearing outlives the old types by two to five times.

About 1936, iron powder was first studied. Iron powder parts are exemplified by oil pump gears for automobiles. In this case, the iron powder is mixed with graphite which not only supplies the necessary carbon for the alloy, but also acts as a lubricant in molding. These gears are sintered at 2000 deg. F. for 20 to 40 min. The tooth surfaces are not machined or finished after sintering, but a small amount is removed in burnish-broaching the hole, machining the outside of the gear, facing the hub to correct length, and champfering the teeth. The gears are oil impregnated before use. Therefore, almost no metal is removed, as compared with the removal by machining of 64 per cent of the material in a cast iron blank for the same application.

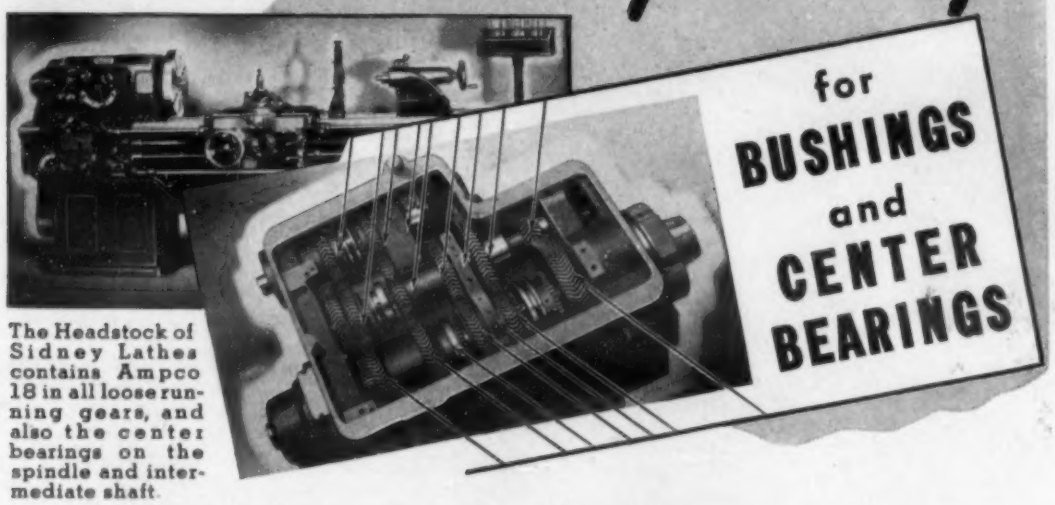
The sintered gears have a smoother surface, are quieter, and weigh 20 per cent less than the cast iron gear. If it were necessary, the tensile strength could be increased by longer sintering at a higher temperature or by heat treatment, but 25,000 lbs. per sq. in. minimum tensile strength has been found adequate for this application. Porous iron bearings are just one example of iron powder parts which include other gears, cams, etc. where wear resistance, surface smoothness, close tolerances, and comparative ease of manufacture are of importance.

It must be remembered that powder does not flow freely, so re-entrant angles cannot be formed. Also length tolerances must be somewhat more liberal than for machining if extra machining costs are to be avoided, and a reasonable limit on eccentricity must be provided. To be commercially feasible, the design must be such as would normally require considerable machining, and a reasonable number of parts must be required.

Other powder metallurgy applications include Alnico magnets (small sizes used in meters and other small electrical devices), tungsten filaments in electric lights, diamond drill bits, radio tuning brakes (iron powder), guide blocks for machine saws (iron powder, impregnated), and electric contacts (silver or copper with tungsten or molybdenum).

—*Machinery*, Vol. 48, Aug. 1942, pages 111-118; Sept. 1942, pages 148-152.

AMPCO "The Logical Alloy"



The Headstock of Sidney Lathes contains Ampco 18 in all loose running gears, and also the center bearings on the spindle and intermediate shaft.

Machine tool designing engineers, critical of the material which enters into each part of the equipment, have often chosen AMPCO METAL for vital parts subject to unusual wear and fatigue. Today 94 machine tool builders are Ampco customers.

AMPCO METAL has been selected because of its high strength-weight ratio, controllable hardness, and marked resistance to wear and failure. Its bearing characteristics are excellent. Note in the accompanying table its high physical properties.

PHYSICAL PROPERTIES OF AMPCO METAL

AMPCO GRADE		TENSILE STRENGTH	YIELD STRENGTH	ELONGATION IN 2"	RED. OF AREA	BRINELL HARDNESS
"	12	65-75,000	25-29,000	22-27%	22-27%	109-124
"	16	70-80,000	32-37,000	18-22%	16-20%	131-156
"	18	77-85,000	34-40,000	10-14%	6-10%	159-183
"	18-22	90-100,000	45-55,000	3- 7%	3- 7%	202-235
"	18-23	95-105,000	43-50,000	10-15%	12-18%	183-207
"	20	83-90,000	38-43,000	2- 6%	1- 4%	212-248
"	21	70-80,000	42,000 min.	1- 4%	0- 4%	285-311
"	22	70-85,000	45,000 min.	0- 2%	0- 2%	321-352

Catalogue 22 describes all grades of AMPCO METAL. Sent free on request.

AMPCO METAL, INC.

DEPARTMENT MA-11 MILWAUKEE, WISCONSIN

AMPCO METAL

THE METAL WITHOUT AN EQUAL

Materials and Design

Condensed from "Product Engineering"

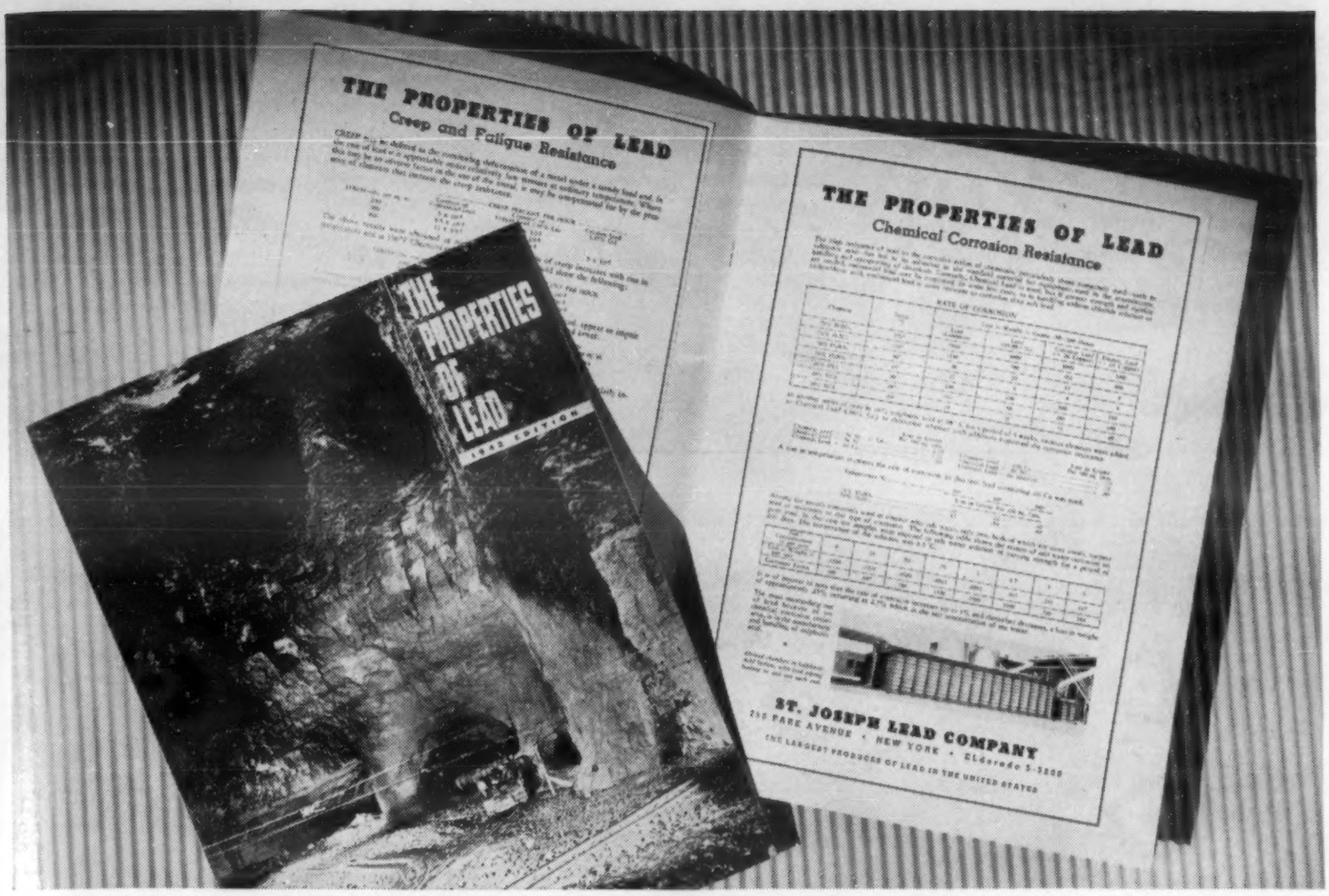
Tests and stress analyses have established the fact that lightweight structures can be designed to be made of any one of a number of different materials with little difference in final total weight.

In addition to tensile strength and density, the following properties of the materials are important in the design of structures: Modulus of elasticity, fatigue strength, ratio of tensile strength to shear strength, corrosion resistance, workability of the material with reference to operations such as bending, machining, resistance welding and fusion welding. They must be considered individually and in relation to each other.

The materials here discussed are laminated plywood, aluminum, stainless steel, low alloy steel, plain carbon steel and magnesium. Composite materials have not yet proved suitable for highly stressed members.

On the basis of tensile strength only, the relative weights of tension members of equal strength would be in the same ratio as the weight-strength ratio of the respective materials. However, there are bound to be shear stresses and therefore in practically every structural calculation the tensile strength of the material is a factor, but in no case is it the only materials property factor.

The ratio of tensile strength to shear strength must be considered. For aluminum this ratio is about 1.6, for steel about 3, but for wood, parallel to the grain, it may be as high as 12 times the corresponding shear strength. For plywood the shear strength may be one-eighth of the tensile strength when the grain directions of the plies are at angles to one another. Because


THE PROPERTIES OF LEAD
Creep and Fatigue Resistance
THE PROPERTIES OF LEAD
Chemical Corrosion Resistance
THE PROPERTIES OF LEAD
1942 EDITION
ST. JOSEPH LEAD COMPANY
250 PARK AVENUE • NEW YORK • ELdorado 5-3200
THE LARGEST PRODUCER OF LEAD IN THE UNITED STATES

USE LEAD

...in place of more Strategic Metals

As there is an ample supply of lead, industry may well endeavor to use it in place of more strategic metals. To help determine whether such substitutions are possible, this Company will be glad to send you "The Properties of Lead". This 8½ x 11" booklet contains reprints of St. Joseph Lead Company advertisements which appeared in various trade publications during 1941. The subject matter of each advertisement is listed at the right. Supplementing these data, pertinent statistics on lead have also been included.

Copies of the booklet may be obtained by writing to this Company.

THE FOLLOWING PROPERTIES ARE COVERED:

1. Tensile Strength and Elongation
2. Hardness and Abrasion Resistance
3. Work Hardening
4. Creep and Fatigue Resistance
5. Atmospheric Corrosion Resistance
6. Soil Corrosion Resistance
7. Galvanic Corrosion Resistance
8. Chemical Corrosion Resistance
9. Thermal Properties
10. Malleability, Pliability and Plasticity
11. Atomic Structure and Properties

ST. JOSEPH LEAD COMPANY

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THE LARGEST PRODUCER OF LEAD IN THE UNITED STATES

the shear strength of aluminum is more than one-half its tensile strength, and for steel about one-third, the shear stress in a tension member is usually not considered. When designing for plywood, the relatively low shear strength of the material will often make it necessary to design the member to resist shear, even though the principal stresses are tension or compression.

In designing the connections for plywood members, the joint must be carefully analyzed for shear stresses if a bolted or riveted connection is used. Shear stresses will be developed in the margins and in the sections between the bolts and lying in the plane determined by the axes of the adjacent bolts, which may exceed the shear strength of the plywood. With metal such a condition is not encountered.

In bolted connections between plywood members, the high yielding of the material, that is, its low elastic modulus and high yielding under stress, results in a load distribution among the bolts and rivets entirely different from that in the case of metal members. Also the bearing load exerted by the bolt tends to split the wood.

The modulus of elasticity determines stiffness and is a factor of the load-carrying capacity of columns and sheets subjected to compression. The load-carrying capacity of a given slender column varies with the modulus of elasticity of the material. When compression members consist of formed thin sheets, load-carrying capacity is usually determined by failure resulting from local buckling rather than as a column. The resistance of the column or compression member to local buckling will vary with the elastic modulus of the material and its yield strength.

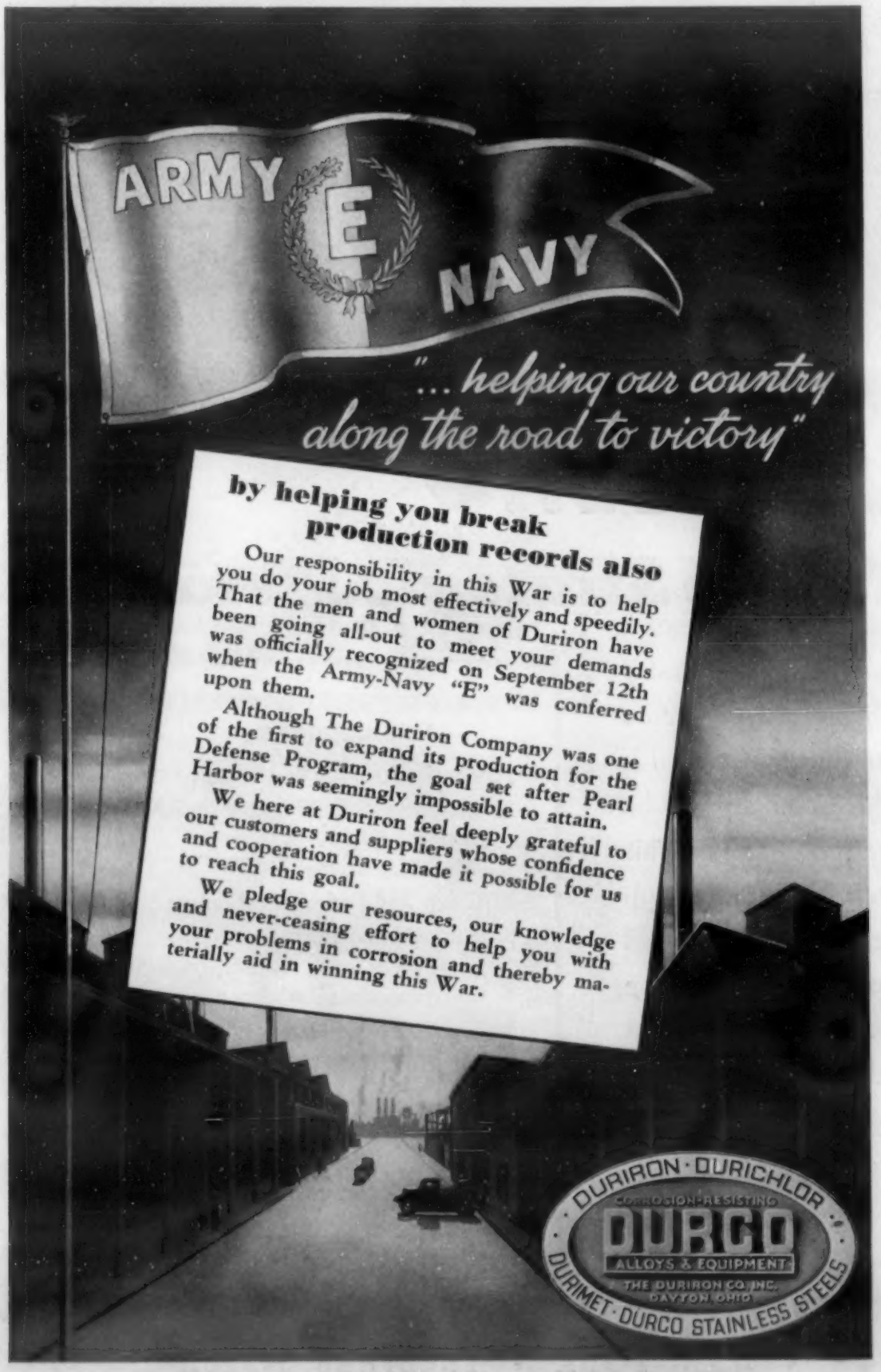
In most constructions, EI—the product of modulus of elasticity times moment of inertia—is the measure of the stiffness of the structure. Therefore, when changing from one material to another, the cross-sectional dimensions of the members must be changed to give a new value to I inversely proportional to the values of E of the respective materials, to retain equal stiffness. Because of the many possible ways of changing the I of a section, the weight of the structure will depend largely on the ingenuity of the designer.

In sheet constructions subjected to compressive stresses parallel to the surface, the strength of the structure is roughly proportioned to the cube of the skin thickness. The desirability of using plywoods in place of metal in shell type structures is based upon the ability to minimize interior reinforcements by virtue of the increased stiffness of the thicker plywood shell.

Three common methods of making connections are: Riveting and welding for metals and gluing for plywood and plastics. Spot welding is preferred when possible. Rivet holes cause some sacrifice in tensile strength.

It appears that future materials may well depend upon where the most effort and ingenuity are applied. New materials will be sought and experiments with composite materials continued.

—*Product Engineering*, Vol. 13, Sept. 1942, pages 530-532.


ARMY
E
NAVY
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Be sure to read M & A's "Annual Engineering Review Issue"——our January number containing some 35 informative articles on 1942's engineering developments in the production and processing of metals and the design and fabrication of war-time metal products. Our annual tabulation of new materials and finishes developed in the past year will be included.

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CONTENTS

Efficient Gaging System 972
Gamma-Ray Weld Tests 976
Oscillograph in Dilatometry 980
Resistance Welding Mortar Fms 982

Efficient Gaging System

Condensed from "Iron Age"

An improved system of gaging developed by the U. S. Army Ordnance Dept. With this system tolerances are within the limits set on the work instead of being centered on the upper and lower limits. Tolerances on the inspection and work gages have been so set with respect to each other as to assure interchangeability of components in mass production.

In this system the difference between work and inspection gages is predicated on a logically and carefully planned system of wear allowances and tolerances, rather than on the application of arbitrary differences. It is based on the fact that gages cannot be built to exact figures but must be made within a permissible tolerances of accuracy; also that they are subject to wear.

It goes further in that work gages, in general, wear out faster than inspection gages due to their greater usage, and that some difference must be allowed between inspection and work gages.

Inspection gage is designed so that the necessary gagemaker's tolerance in producing the gage is applied within tolerances shown on the component drawing; and in addition, a wear allowance is provided, also within the tolerances shown on the component part drawing.

Work gage is designed so that it also has gagemaker's tolerances and a wear allowance applied to it, not only within the limits shown on the component part drawing, but also within reasonable limits shown on the inspection gage, so that the work gage may have a reasonable life of usefulness. Gagemaker's tolerance and wear allowances are both charted for all of the component tolerances usually encountered in steps of 0.001 in.

In the wear gage for a component tolerance of 0.005 in., the wear allowance for the Go side is 0.0007 in. and the gagemaker's tolerance is 0.0002 in. For instance, starting with the maximum component limit of 1.7550 in. the 0.0007 in. wear allowance for the Go side of a snap gage is subtracted, and the 0.0002 in. gagemaker's tolerance is applied in the minus direction. Subtracting 0.0007 in. from 1.7550 in. leaves 1.7543 in. which on the Go side is a tolerance of —0.0002 in.

If the work gage wear allowance on the Not Go side is 0.0002 in. and the gagemaker's tolerance is also 0.0002 in., both are applied in the plus direction. The 0.0002 in. wear allowance is therefore added to the minimum component limit of 1.7500 in. to give the size to which Not Go side of gage must be made, in this example 1.7502 in. Marking on the work gage is a signal to the gage inspector that, once the gage has worn to that figure, it must be replaced.

For this inspection gage, if there is a tolerance of 0.0005 in., wear allowance is 0.0003 in. on the Go side, and the gagemaker's tolerance is 0.0002 in. No wear allowance is provided on the Not Go side of the inspection gage as the part seldom enters it, but the gagemaker's tolerance of 0.0002 in. is applied in this case

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Liquadol and Liquafix are available from authorized dealers or if you are near one of the Agfa Ansco branch offices listed here, a telephone call will bring you complete information. Or a postal card or letter to our main office will bring a prompt response. *Agfa Ansco, Binghamton, New York. Branches in Boston, New York, Cincinnati, Chicago, Dallas, San Francisco, Los Angeles, and Toronto.*

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in a plus direction. This is the direction of safety. Another reason for not using a wear allowance on a Not Go gage is that it would have to be outside the component limits. These illustrations dwelt on male components parts and female gages. However, same data can be applied to female parts and male gages by using the data in the opposite direction.

Equipment in the arsenal gage laboratories includes:

(1) Standard measuring machine with a vernier scale and microscope by which readings are taken within 0.00001 in.

(2) Comparator using electrical means of amplification to indicate inaccuracies as compared to master of known accuracy.

(3) Optical projection comparator with magnifications ranging in steps from 12 to 100 diameters.

(4) Universal measuring microscope for contour, coordinate or angular measurements which are taken by means of a cross hairline setting in comparison with one of the standard glass scales. Results are read through two spiral micrometer microscopes with an accuracy of 0.00005 and

(5) Light wave measuring equipment, consisting of two semi-quartz optical flats or hard clear glass, neither having any magnifying power, which are ground and polished until one surface of each is flat within 0.00002 in. In addition, there is a set of master precision gage blocks, and a monochromatic light of one color and wave length for checking flatness, parallelism and size of small parts, and for detecting worn parts.

A new instrument developed is the multiple purpose electric contact gage, by which all surfaces are gaged simultaneously. Flashing lights indicate to the operator by their color whether or not the part will pass. Warning light designates exactly which point or surface is at fault.

Pneumatic gaging devices for certain type of fuse and also for gaging gun bores have also been developed.

—J. B. Nealey, *Iron Age*, Vol. 150, Sept. 3, 1942, pages 45-50.

Gamma-Ray Weld Tests

Condensed from "The Welding Engineer"

The use of gamma rays for photographing interiors of thick sections of steel plate was conceived by Mehl in 1928. The gamma rays are shorter than X-rays (0.01-1.4 Å. as compared with 0.06-120 Å.), so they can penetrate 11 to 12 in. of steel as compared with about 8 in. for the million volt X-ray machine. The radium salt generally used in industrial radiography is the insoluble sulphate. The salt is sealed in an air-tight silver capsule as the radon continually produced is an extremely dangerous gas. This capsule is placed within a container of aluminum alloy or steel to prevent accidental crushing. However, such a container is not a shield against radium rays.

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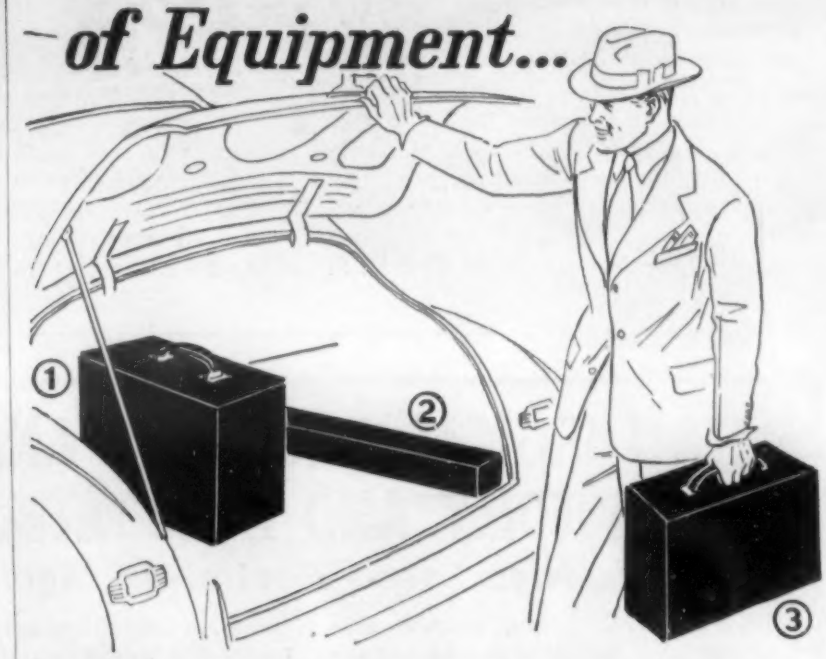

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tance; for example 4 ft. is given as a safe distance for a daily exposure of 200 mg-hr. A lead-lined portable carrying case should be used for transporting the radium container to the work. Standard X-ray films are generally used, but a new high speed film especially developed for gamma rays is now available.

To secure a sharp image, the film should be as close as possible to the object being radiographed, but decreasing the distance between the radium and the film will decrease image definition. Therefore, a comparatively long distance from film to radium is best in general practice, but this necessitates either a large radium source or a long exposure time. The U. S. Navy recommends a minimum radium-film distance of 10 in. for a steel thickness of 3 in. and a radium source of 100 mg. Since the capsule radiates gamma rays in all directions, several objects may be examined at once by arranging them in a circle around the radium.

One of the most useful charts for determining exposure time is the Naval Research Laboratory's circular slide rule. To obtain the exposure for any metal other than steel, it is necessary to take the density of that particular metal into consideration (higher density requires longer time). Navy specifications require the use of lead intensifying screens about 0.006 in. thick, which are sandwiched between the films in the cassette in a lead-film-lead-film-lead arrangement to intensify the radiation and decrease exposure time.

Porosity, slag inclusions, lack of fusion and cracks are the common welding faults revealed by gamma rays.

Gamma-ray radiography has many advantages including portability, penetrating power, and lack of scatter as compared with X-rays. Moreover the initial investment or monthly rental cost is virtually the only expense. On the other hand, X-rays are faster and more sensitive (especially on thin plates. On steel plate under 2 in. thick, X-ray sensitivity is about 0.5 per cent of the total thickness; gamma ray is only about 2 per cent.) However, the lesser sensitivity of gamma rays can at times be a decided advantage if examining objects of varied or irregular thickness.

X-rays and gamma rays are really not competitive, since each method is well suited to its own particular field and specific tasks.

—C. B. Clason, *Welding Engr.*, Vol. 27, Sept. 1942, pages 35-39.

Oscillograph in Dilatometry

Condensed from "Transactions" of the American Society for Metals

The fundamental basis of all hardenability tests is dependent on factors which control critical cooling velocity. Use of string galvanometer to determine this critical cooling velocity by time-temperature curves is satisfactory in most cases, but response, sensitivity, and ease of operation are limited.

The authors developed the cathode ray oscillograph for recording these curves. Apparatus consists of:

(a) Electric furnace to heat specimen in vacuum to desired temperature;

(b) Mechanism to move specimen rapidly from furnace into quenching chamber where steel is quenched at desired rate by introducing nitrogen (rate of quenching is varied by changing pressure of nitrogen);

(c) Thermocouple amplifier circuit to permit use of cathode ray oscillograph to follow changes of e.m.f. generated by thermocouple spot welded to steel disk specimen;

(d) Cathode ray oscillograph to indicate time-voltage changes on fluorescent screen;

(e) Means of recording observed changes on fluorescent screen.

The cascade connected 2-stage DC amplifier is described in detail. The cathode ray oscillograph is based on the fact that an electron beam will be deflected instantaneously when brought within the range of influence of an electrostatic field.

Its main advantages over the string galvanometer are its instantaneous response to voltage changes, its ease of calibration, and its accurately controlled time axis

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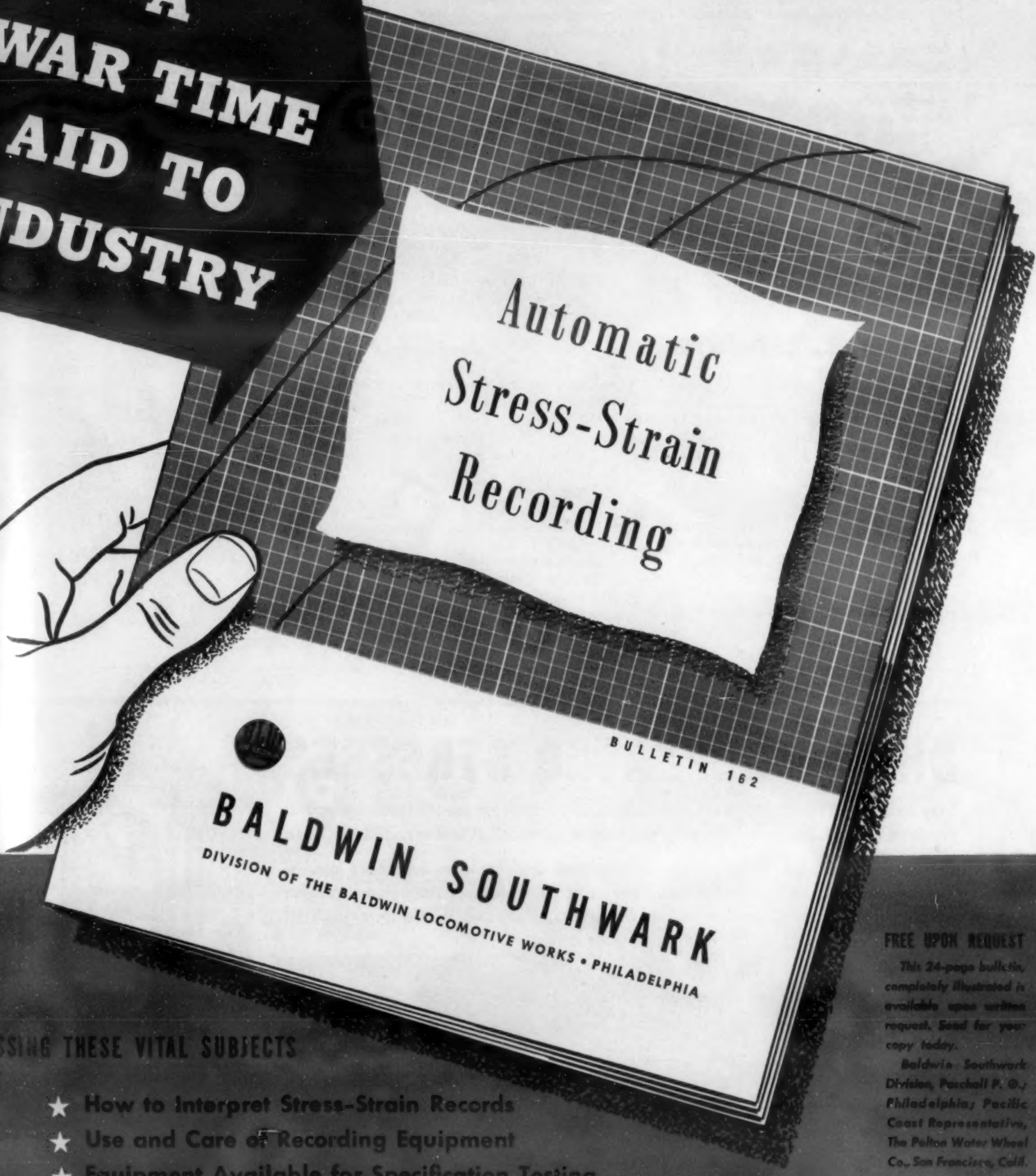

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which is an AC current of suitable wave form. The oscillograph is calibrated with specific impressed millivoltages. The indications on the fluorescent screen are recorded with a camera using a Super-Panchro-Press film.

Examples of use are given, including determination of a cooling rate as high as 12,700 deg. F. per sec. between 1212 and 612 deg. F.

—C. R. Austin, R. M. Allen, and W. G. Van Note, *Trans. Am. Soc. Metals*, Vol. 30, Sept. 1942, pages 747-773; discussion pages 773-775.

Resistance Welding Mortar Fins

Condensed from "Welding Journal"

For purposes of research into the characteristics of welds and welded trench mortar fin assemblies, four individual contractors submitted lots of 25 assemblies each. Of these, 10 were made at the beginning of a run with freshly dressed welding electrodes, 5 in the middle and 10 at the end of the run. The identity of the contractors was not known to the author. They were identified as A, BW, CW and DW.

Eight radiographs of eight welds were made for each lot and, of each assembly radiographed, two diametrically opposed pairs of welds were radiographed. No radiographs showed any cracks, but the general appearance of the majority was commensurate with standards of incomplete fusion. Welds made by each contractor were sectioned and the hardness checked using a Vickers' diamond pyramid hardness tester.

The two tests which indicated results of such a nature as to permit drawing comparisons between different lots of samples were the tensile and metallographic tests. The metallographic tests indicated many unfused weld centers which checked the appearance of welds fractured by the tensile test. The tensile test fractures showed the unfused weld centers and gave quantitative values of tensile strength. For production tests and comparison of welding schedules it is recommended that only tensile tests be used as a criterion of quality.

Inspection of the tensile test values indicated that welds made by contractor BW are superior to the other three, among whom there is no choice. In the majority of BW contractor's samples, the fins broke before the welds at an average value of 2369 lbs. for two welds or 1185 lbs. per weld.

Three factors contributing to the superiority of the welds made by BW are:

(a) Use of multiple pulsation weld timing instead of single pulsation timing.

(b) Use of welding electrodes so shaped as to concentrate welding pressure on an area approximately ¼ in. in diameter, such area concentric with the projections in the fins.

(c) Location of projection with reference to the groove and threads when such are present.

The heat and pressure of welding tend to reduce the diameter of the bore of the threads or of the plain bore if threads are not present. If the dimension is as large as possible, as in the case of BW compared with the other contractors, more welding time and current may be applied to get stronger welds without getting excessive bore shrinkage. The welding of the assembly with no threads is preferable, if consideration is given only to obtaining the strongest welds.

—J. H. Cooper, *Welding J.*, Oct., 1942, pages 501s-506s.

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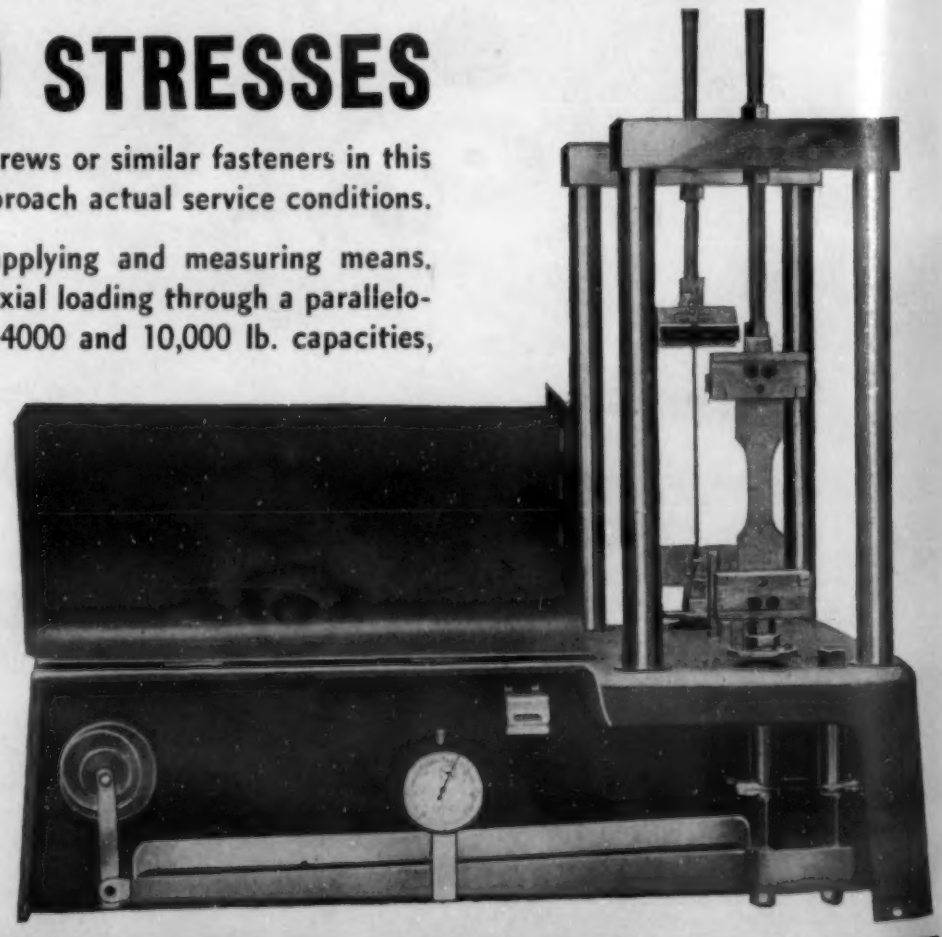

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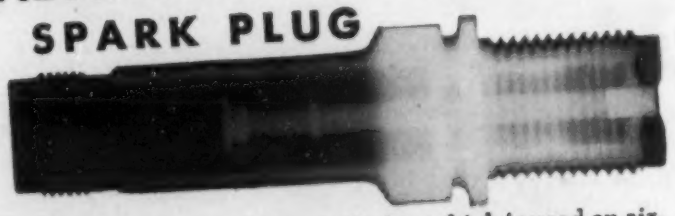
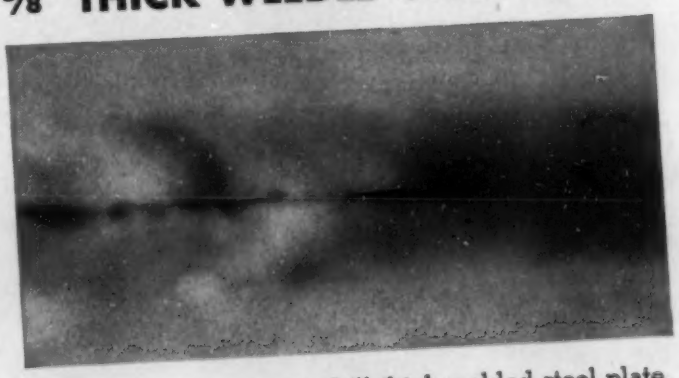
SPARK PLUG



This is a radiograph of a spark plug which is used on aircraft engines. The purpose for radiographing this spark plug was to show the manner in which the internal electrode had been assembled inside of the plug. The main interest lies around the copper gasket at the upper and lower ends of the ceramic insulator which forms the internal structure of the plug. So far as we can determine, there are no defects in the assembly.

5/8" THICK WELDED STEEL PLATE



This is a radiograph of a 5/8" thick welded steel plate. The radiograph readily shows that the weld has not been complete throughout the section of the plate. This fact is indicated by the dark line running through the center of the radiograph. The darker area on either side of this line indicates that the weld has not been built up into a bead on top of the plate, but instead the plate has considerably less thickness at the junction of the weld than throughout the rest of the area.

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FOR METALLURGICAL ENGINEERS

Refractories

REFRACTORIES. *By F. H. Norton. Published by McGraw-Hill Book Co., Inc., New York, 1942. Cloth, 6¼ x 9¼ in., 798 pages. Price $7.50.*

The first edition of this popular book appeared in 1931. The present edition is considerably enlarged, having expanded from 594 to 798 pages. Several new chapters have been added, notably one of approximately 100 pages on "Some Fundamental Concepts of Matter in the Solid State." As in the former edition, one of the most valuable parts of Norton's book is the excellent bibliography at the end of each chapter.

The same general criticism can be made of the second as of the first edition, namely, the book relates primarily to fireclay refractories and not to refractories in general. In the United States, Europe and Great Britain the use of chrome-magnesite and magnesite-chrome brick has increased by leaps and bounds, but these are only superficially treated in Norton's book. Even in the chapter on refractory raw materials the important products, magnesite and chrome ore, are only lightly touched on. Likewise the method of forming and making refractories are those largely used in the fireclay industry.

Although Professor Norton is a member of the Committee C-8 on Refractories of the American Society for Testing Materials, he has not brought the test methods up to date. As an example, on pages 87 and following, he gives the old test method C24-35 for Pyrometric Cone Equivalent of refractory materials. The method was revised in 1940. The size of the cone, for example, has been changed. He gives the ASTM method C16-36 as the standard method of test for refractory materials under load at high temperature but this test was revised in 1939 and a new method made tentative in 1941. The ASTM has withdrawn all load tests for silica brick and has changed the schedules of heating from those given in page 442 by Norton.

In this connection Norton gives a load test for moderate heat duty fireclay brick. This classification was removed from the ASTM standard classification several years ago. On page 481 the panel spalling test for high-heat duty fireclay brick is an old method revised in 1940 and further tentatively revised in 1941. The heating schedule, for re-heat tests of various types of refractories, given on page 535 and referring to ASTM Test C113-36, is out of date by not having included schedule D. The reader, therefore, should consult the ASTM Standards on Refractory Material rather than Norton's book for test methods.

The first edition of Norton's book was good; the second is an improvement, and as applied to fireclay refractories it is quite adequate. It is deficient so far as basic, neutral and special refractories are concerned. The book will serve as a text book in certain courses in refractories, and the bibliography references are commendable. The book can not be recommended as a general reference book on refractories, although as applied to fireclay products it is quite authoritative.

—JOHN D. SULLIVAN

Metal-Working Processes

MANUFACTURING PROCESSES. *By Myron L. Begeman. Published by John Wiley & Sons, Inc., New York, 1942. Cloth, 6¼ x 9¼ in., 379 pages. Price $4.50.*

"Written primarily for students" this book presents in well-organized fashion the elements of "metal working" that the student engineer should know. The title seems to be too general, however, since there are many manufacturing processes not covered — including some metal-forming processes, as well as several non-metal "manufacturing processes." (Actually the book covers in a simpler way the same material presented in another recent Wiley book, "Metal Processing," by O. W. Boston, reviewed in the June 1942 issue of METALS AND ALLOYS, page 1082.

The volume may be roughly divided into 2 halves. The first 9 chapters are on metal-casting, treating, welding and inspection processes (including a chapter on plastic molding), and the last 10 chapters on machining operations and machine tools. The chapters on machining and machine tools are up-to-date descriptions of the general operations and the types of equipment used. From the student-engineer's viewpoint, we think more attention could have been given to the machinability of different materials in different operations and to the relative performance abilities of the various tool steels, carbides and other tool materials.

The first 9 chapters — on foundry practice, die casting, plastic molding, heat treatment of steel, welding, hot and cold forming and inspection — suffer from a necessary compression into too small a space, and consequent omission of several processes and of many details of those covered. The volume contains no information on cleaning, plating and finishing, on powder metallurgy, on wire drawing and on flame-cutting, for example, and very little on permanent-mold casting, drop forging and the heat treatment of tools — all of which can conceivably be classed as "manufacturing processes" on a par with die casting, welding, hard-surfacing and others actually covered in considerable detail in the book.

It is still a good book, however (anybody can find omissions in *any* text) and can be recommended as fulfilling its purpose.

—FRED P. PETERS

Other New Books

THE OCCURRENCE AND PRODUCTION OF MOLYBDENUM. *By John W. Vanderwilt. Colorado School of Mines Quarterly, Published by the Colorado School of Mines, Golden, Colorado, 1942. Paper, 6 x 9 in., 78 pages. Price $1.50.* This little book is full of information and data on molybdenum. Some of the topics which are discussed give a comprehensive idea of its broad treatment: Properties and Uses, Production, Future of Molybdenum, Mining and Concentration, Distribution, Molybdenum-Bearing Minerals, Occurences of Molybdenite, Deposits of Molybdenite, 1942, in the United States and outside. An extensive bibliography is included.

COLD FINISHED BAR STEELS. *Published by Bliss & Laughlin, Inc., Buffalo, N. Y., 1942. Flexible binding, 6¼ x 9¼ in., 228 pages. Free to engineers and executives who request it on their business letterheads.* One of those extraordinarily useful and interesting books published by a manufacturer but with only an imperceptible amount of "sales talk." Contains a 75-page technical section on machinability, treatment and applications of cold finished steel, and about 80 pages of reference tables, plus some 40 pages on B&L production methods.

B&L SUPPLEMENT, MANUAL OF COLD FINISHED STEELS, SECTION I. *Bliss & Laughlin, Inc., Buffalo, N. Y., 1942. Looseleaf, with ring-binder covers, 6¼ x 9¼ in., 52 pages. Free to engineers and executives who request it on their business letterheads.* This first section includes technical data on cold finished bar steels and shafting. It contains comparative tables showing the designations and chemical compositions of the standard AISI and SAE grades, as well as the new "NE" series of national emergency steels, all under the 1942 classifications. Additional sections will be published from time to time, so as to provide an up-to-date reference book for steel users.

METALLURGICAL ENGINEERING news

Equipment • Finishes • Materials • Methods • Processes • Products
Alloys • Applications • Designs • People • Plants • Societies

Spot Welding and Heat-Treating Combined

The "Temp-A-Trol" forge welder combines automatic spot welding and heat-treating of alloy steels and heavy sections, and allows less skilled labor. The weld itself automatically controls the functioning of the machine. Without changing the machine control, welds of exact quality can be produced consecutively in ¼ to ¼ in., in 3/16 to ¼ in., in ¼ to ⅜ in., or in three sections of ¼ in. material at the same time.

The heat-treating feature of the machine refines the grain size of the weld, increasing its ductility, gives the proper grain structure, and "tempers" the weld nugget and adjacent area to any desired amount.

Another feature is "Frostrode," which maintains below-freezing temperatures at the electrodes while the material between them is heated to "melting" temperatures.

In the accompanying photo is shown the complete welding installation—left to right: the welder, control cabinet, contactor unit, and "Frostrode" refrigerator cabinet. The equipment is made by the *Progressive Welder Co.*, Detroit.

● *Bell & Gossett Co.*, 8200 Austin Ave., Morton Grove, Ill., is now building industrial wash tanks "to meet exactly every specialized requirement." One of these is a three compartment tank for castings in a large defense plant. Castings are passed successively through cold kerosene, hot Oakite and hot water. Operation and temperature control are entirely automatic.

Dr. Woldman Heads A. F. A. Section

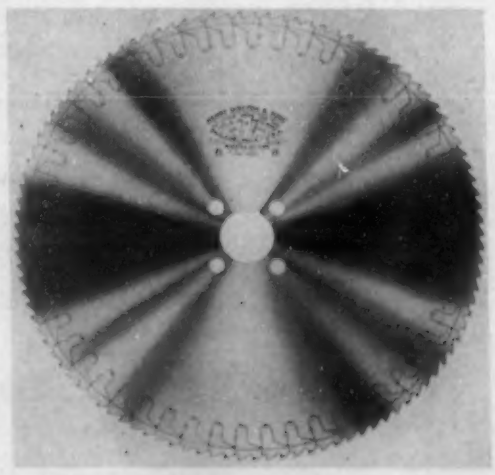
The newly-organized Aluminum and Magnesium Division of the American Foundrymen's Association will be headed by Dr. N. E. Woldman, chief metallurgical engineer, Eclipse Aviation Div., Bendix Aviation Corp., Bendix, N. J. This new division will study foundry practices involved in the casting of aluminum and magnesium alloys through cooperative work of the members of these branches of the foundry industry.

Dr. N. E. Woldman has enjoyed an extremely varied career as metallurgical engineer, teacher and author. He attended three Ohio colleges, including Case School of Applied Science and received his Ph.D. degree in chemical and metallurgical engineering at Columbia University. He has taught in the Universities of Maine and Illinois, U. S. Naval Academy and Carnegie Institute of Technology. Among his positions in industry have been those with Westinghouse Electric & Mfg. Co. and U. S. Naval Gun Factory, Washington. He is a member of several technical societies.

Inserted Sections Instead of Saw Teeth

Here is a circular metal cutting saw with inserted sections rather than inserted teeth. It permits a thinner blade and cutting edge than the individual inserted teeth type, cuts a narrower kerf and uses less power.

It is made by *Henry Disston & Sons, Inc.*, Philadelphia, can be sharpened on an automatic grinder, provides a maximum number of teeth for any diameter, and cuts extremely smooth. It can be operated up to 5,000 ft. per min. Inserts are easily replaced if damaged. To be refitted, it does not have to be returned to the factory, the work being simple.



Acid Open-Hearth Research Association

The Acid Open-Hearth Research Association was formed in Pittsburgh on September 14th to conduct practical and technical research upon the problems governing the production of steel in the acid open-hearth steel furnaces. Nineteen steel and related companies became members at the time of formation, but there may be other potential members, the association inviting all eligible companies to become members.

Dr. G. R. Fitterer, Department of Metallurgy, University of Pittsburgh, has been appointed director of research, with J. W. Linhart named research metallurgist. The work will be conducted by Dr. Fitterer under the auspices of the University of Pittsburgh in conjunction with a complete study of actual furnace heats in plants of member companies.

Officers of the association are: Chairman, H. G. Grim; vice-chairman, Dr. F. H. Allison; secretary, F. C. T. Daniels; treasurer, R. C. Heaslett. The executive committee comprises: George S. Baldwin, H. E. Dowie, Walter H. White, J. S. Zahn, J. L. Nichols, E. H. Harder, E. H. Nebs, W. E. Harvey and Herman P. Rassback.

R-S

QUALITY PRODUCTS SINCE 1908

A Sign of RELIABLE Heat-Treating SERVICE

This R-S name plate on an industrial heat-treating furnace is more than a means of identification—it is the stamp of approval of R-S Engineers.

It guarantees top notch production due to proper design, erection and operation.

It guarantees that the entire equipment is geared to individual plant conditions and the type of heat-treated product involved.

It assures minimum fuel consumption and the conservation of manual effort with maximum safety.

For heat-treating efficiency and economy, today or tomorrow, specify R-S Industrial Furnaces.

If you have an industrial heat-treating problem, write on your company letterhead for helpful suggestions.

FURNACE DIVISION

R-S PRODUCTS CORPORATION

4522 Germantown Ave., Philadelphia, Pa.

R-S Furnaces of Distinction

BUY WAR BONDS

Powdered Metals Institute Formed

The Powdered Metals Institute has been formed by twelve companies using powder metallurgy processes to serve as an advisory council to the Army and Navy in adapting powder metallurgy to war production. Headquarters are in Saginaw, Mich.

Officers are: Chairman, L. E. Field, vice president, United States Graphite Co., Saginaw; vice chairman, A. J. Langhammer, president, Amplex Div., Chrysler Corp., Detroit; secretary, E. S. Patch, sales manager, Moraine Products Div., General Motors Corp., Dayton, Ohio.

Sodium Light for Flaw Detection

Sodium light, effective in lighting motor highways, is being used in several war plants for surface inspection by microscope because of its efficiency in detection of pits, cracks and flaws in materials.

The unusual perception of detail under sodium illumination is due to the monochromatic nature of the light, according to H. A. Breeding, *General Electric Illuminating Laboratory,* Schenectady. The eye focuses only one narrow wave or color band at a time. Other colors in the beam tend to fog the picture. Thus, in inspection, minute details may be lost under light containing all wave bands in contrast to monochromatic light, with its one wave length. The eye is most sensitive to the sodium band light, the most common color.

It is helpful in searching for cracks and blow holes to treat the part with a light-absorbing or light-reflecting dye, the dye depending on the nature of the surface. One blocks out as much sunlight as possible so as not to destroy the monochromatic nature of the sodium illumination.

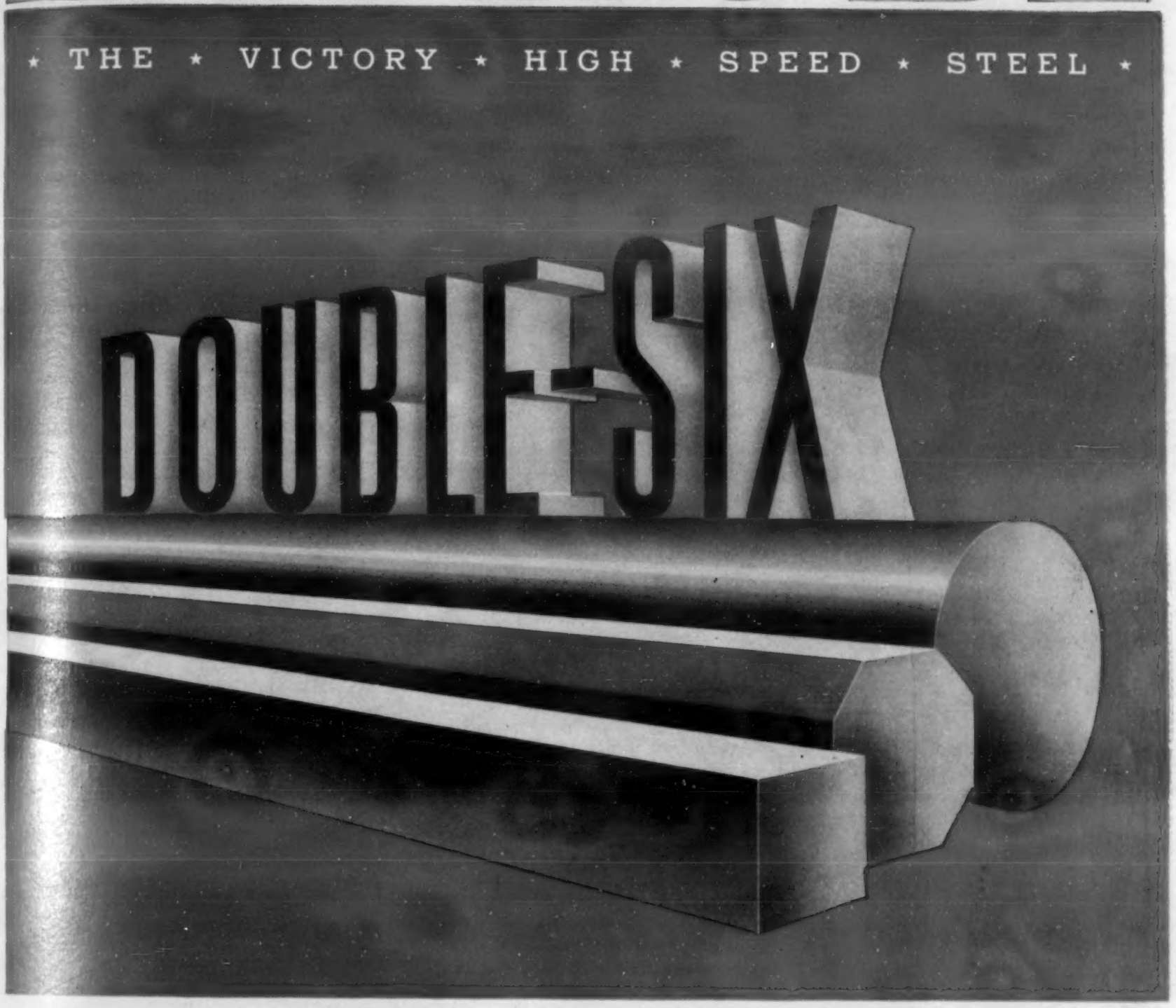
New Cutting Oil

Eight properties of various oils have been blended to produce "Cut-Aid," a new cutting oil developed by *Gulf Oil Corp.* In a demonstration it was used on a machine throwing up a plume of smoke while operating 100 surface ft. per min. When "Cut-Aid" was added to the cutting lubricant already in use, there was no smoke trace at 300 ft. per min. At another plant, tool life was extended from 3 hrs. between regrinds to 11 hrs. in forming aluminum on an automatic.

Often aluminum can be machined so smoothly it does not need polishing. It is excellent for cutting magnesium and non-ferrous alloys. The new product is a result of eight years' study in animal oils.

LATROBE

★ THE ★ VICTORY ★ HIGH ★ SPEED ★ STEEL ★



★ Effects urgent savings in Tungsten, Molybdenum and Vanadium.

★ The superior Tungsten-Molybdenum high speed steel for all industrial cutting operations.

★ Can be readily heat-treated to attain maximum efficiency.

Write for Bulletin

Latrobe ELECTRIC STEEL COMPANY

MAIN OFFICES *and* PLANT · · LATROBE · PENNSYLVANIA

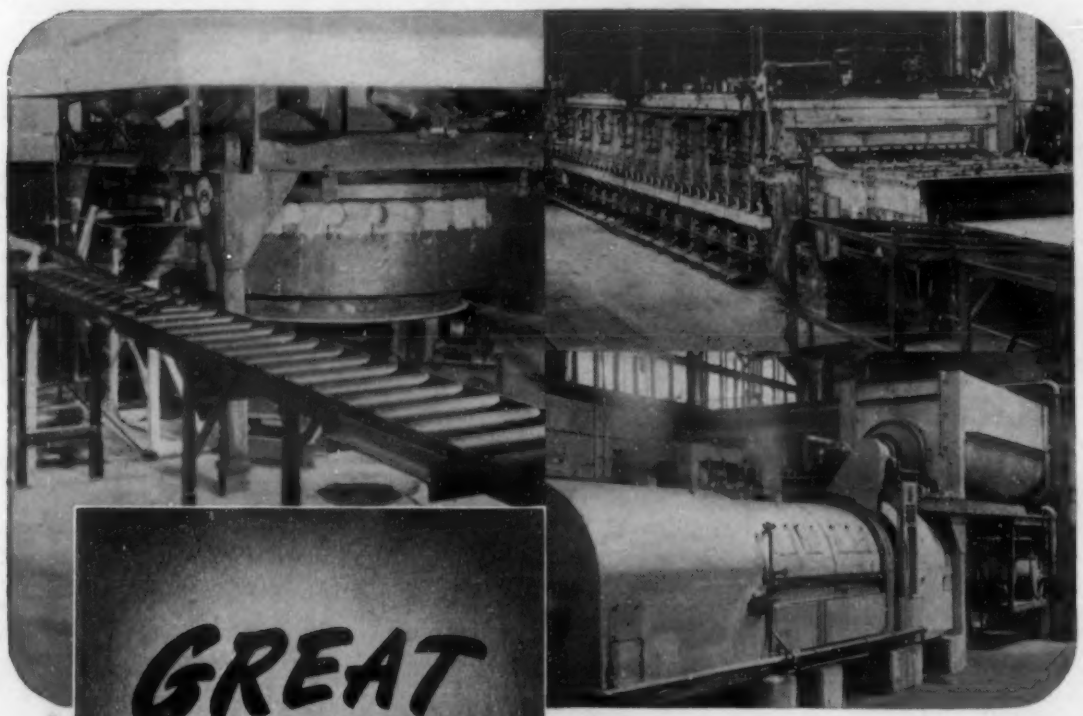
Plants and Slants

What the owners describe as the "world's largest magnesium foundry," with an anticipated monthly production of over 500,000 lbs. of castings, is rapidly nearing completion at 4900 Bloomingdale Road, Chicago, according to Frank C. Howard, president of the *Howard Foundry Co.* The company recently acquired the *Aurora Foundry Co.*, Aurora, Ill., which will hereafter handle the production of all Howard brass, bronze and copper castings and be known as the Bronze Division, while the original foundry will be known as the Aluminum Division. The new plant has already developed processes for making magnesium castings of a much larger size than have been hitherto commercially practical. Single castings up to 7 and 8 ft. in diameter will be part of the normal output.

Steel Heddle Mfg. Co., Philadelphia, manufacturer of loom harness equipment, nas bought the business of J. F. Johnson & Co., Philadelphia, which for 32 years has been manufacturing precision tools, ordnance gages and special machinery.

Employees of the *Carnegie-Illinois Steel Corp.*, U. S. Steel subsidiary, are to be paid $10 each for suggestions that are accepted for furthering production. Suggestion boxes will be provided throughout the mills and offices.

Kieley and Mueller, Inc., manufacturers of automatic pressure and level control valves and equipment, a 63-year old concern, has expanded its factory to triple the size of the former plant at Newark. The new factory and general office covers an entire city block at North Bergen, N. J., from 42nd to 43rd St. and through from Tonnelle Ave. to Bell Ave. The new factory is among the most modern steam specialty plants in the country.



AGAIN ROCKWELL ENGINEERS BOOST WAR PRODUCTION!

A new Rockwell Gas Fired Unit hardens, quenches and tempers high explosive shells in one continuous operation. A single operator places shells on the conveyor at the charge end of the hardening furnace — thereafter all operations are continuous. Both the hardening and draw furnaces are provided with automatic proportioning burners and control instruments so that any draw specified by the Ordnance Department may be easily obtained.

Shells are carried through both furnaces by an oil hydraulic pushing system with time cycle control. The method of quenching gives a very uniform hardness and minimizes any danger of soft spots due to vapor pockets or other causes.

If MORE PRODUCTION is your problem, write or wire us. Rockwell's wide experience in heat treating will help you.

W. S. ROCKWELL COMPANY
50 Church St, New York

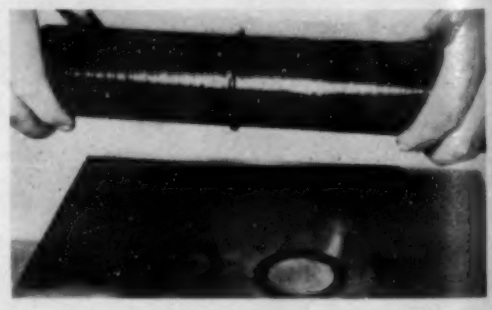
ROCKWELL
ELECTRIC AND FUEL FIRED
FURNACES

Plastic Pipe

A new plastic pipe, made in the same dimensions as extra strong steel pipe of 2-in. outside diam., or less, is announced by the *Dow Chemical Co.*, Midland, Mich. It has resistance to extreme moisture, chemicals and solvents, and much strength and fatigue life. Only a few solvents have adverse effects. It can replace vital metals and rubber.

This new thermoplastic resin is called Saran. The base resin is odorless, tasteless and non-toxic. The plastic does not burn and has high toughness and abrasion resistance. It is non-scaling, withstands freezing, and resists heat up to 175 deg. F. It can be welded, heated and bent; it can be cut with a wood or hack saw and threaded with ordinary iron pipe dies. Lightness is a decided advantage.

In welding the pipe, pieces are placed on a plate heated from 350 to 400 deg.

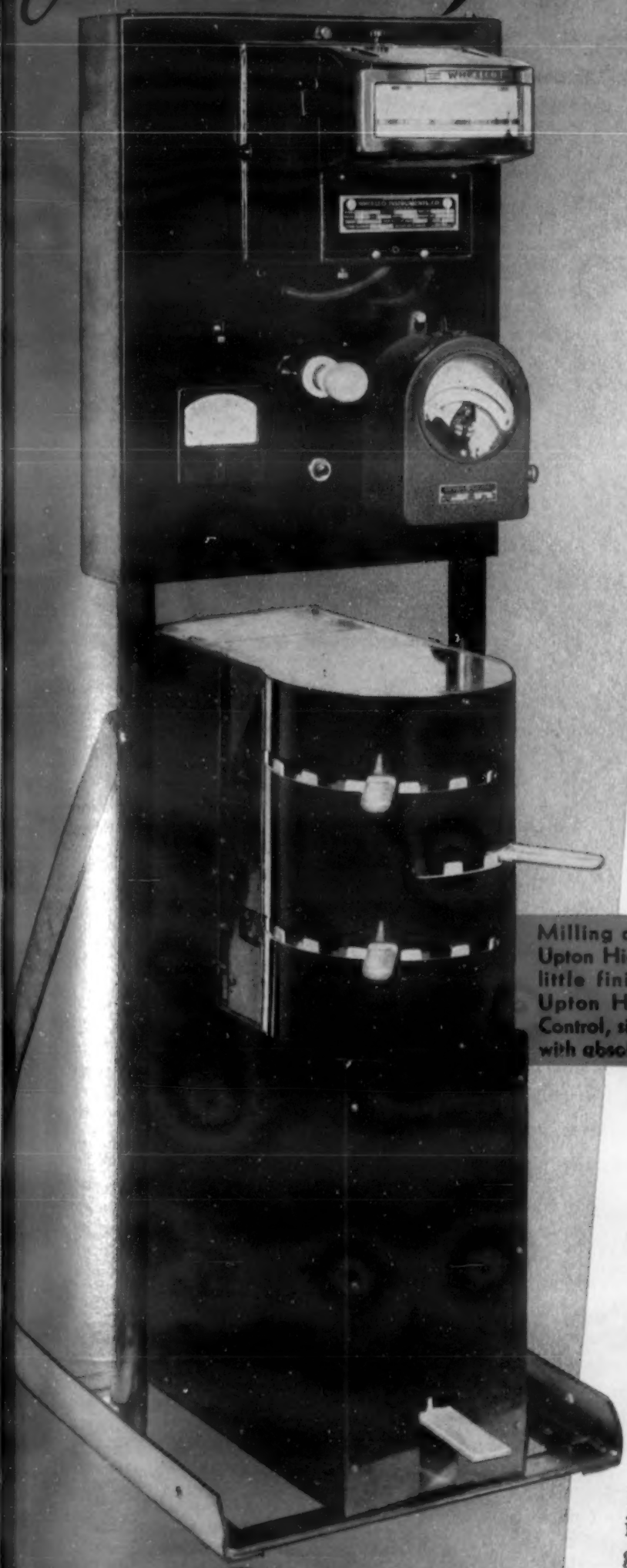


F. and held until molten material appears. Pieces are then placed together in proper position, pressed firmly, as shown in the accompanying photo, and allowed to cool for 10 sec. The resultant weld has greater joint strength than the pipe itself.

• A clearing house for consultants as a free service has been established by the *Association of Consulting Chemists & Chemical Engineers, Inc.*, 50 E. 41st St., New York.

Announcing The NEW UPTON HEAT MEASURING CONTROL

Heat Treating Temperature Control for Upton Salt Bath Furnaces



- ★ **Adds the exact amount of heat for the correct time needed.**
- ★ **Unbelievably accurate temperature control.**
- ★ **Corrects operator's setting errors.**
- ★ **Permits prediction of size change to closer limits.**
- ★ **Eliminates finish-grinding on many High Speed Steel tools.**

The new, tested and proved UPTON Heat Measuring Control temperature controller adds the exact amount of heat for any piece of work, puts the heat into the salt bath for the exact period it is required and then, when the time is up, shuts the heat off and tells the operator to take the work out.

In use for many months on some of the most difficult heat treating operations—where operators with no previous knowledge of heat treating are turning out perfectly treated, high speed steel cutting tools—the Upton Heat Measuring Control even warns the operator if he makes an error in excess of 3°F. in setting the control!

Milling cutters hardened in this Upton High Heat Furnace require little finish-grinding. With the Upton High Heat Temperature Control, size change is predictable with absolute certainty.

Unlike the conventional "on and off" control with its wide fluctuations, the Upton Heat Measuring Control varies between a "high" and "low" temperature value, rather than an "on" and "off". The current supply never goes "off" except when the operator has made an error. Then it shuts "off" and warns him.

The Upton Heat Measuring Control and a battery of High Temperature Furnaces do not require help experienced in heat treating. All Upton Furnaces, as well as pots are guaranteed. Tell us about your heat treating problem.

Send Now... **for more information about the New Upton Heat Measuring Control.**

UPTON ELECTRIC FURNACE DIVISION
Commerce Pattern Foundry & Machine Company

We build the furnace using the **ELECTROTHERMIC-PERMEATION** *principle of operation*

7425 MELVILLE at GREEN • DETROIT, MICHIGAN, U. S. A.

Automatic Arc Welding Equipment

Complete equipment for automatic arc welding with heavily coated electrodes in cut lengths is announced by *General Electric Co.* By means of it automatic arc welding heads originally designed for operation with thyratron-controlled coiled electrodes can be converted for successful welding with stick electrodes.

It is suited to work where one or more complete joints can be made with a single electrode where the starting and finishing ends of a single weld bead overlap. It has been used to make edge, lap, fillet and groove welds.

Hyper-Milling Shears—Not Digs

A new process, called hyper-milling, shears the metal off instead of the conventional digging off. The usual milling cutter is like a carpenter's plane that digs into the work; hyper-milling is like a carpenter's scraper where the tool angle is reversed.

The process uses Firthite *(Firth-Sterling Steel Co.,* McKeesport, Pa.) sintered carbide-tipped inserted blades, with both the rake and helix angles of the mills negative up to 10 deg., cutters operating up to 10 times normal speeds, with feeds up to 6 times those normally used on hardened alloy steel parts. The resulting surface is

burnished, and there is less tool wear and heat. Production has been increased 100 to 300 per cent. It is particularly applicable to hardened, heat-treated steels, including alloy.

The photo shows the cutter in action on annealed alloy tooled steel at 419 revolutions per min., with 1/16 in. depth of cut, with feed of 5¾ in. per min.

• By the last train to leave free Czechoslovakia there came to Britain the drawings for a new type of soldering iron which has beaten everything else for speed in Britain's aircraft, radiolocation and tank factories. Put to its first speed test at radio control and transmitting stations, the tool is now supplied from a South Wales Factory at the rate of three to four thousand a week to radiolocation centers, airdromes, shipyards, ordnance factories, telephone exchanges and in a wide range of general factories. It is equally effective with the new soldering alloys with lower tin content introduced to save stocks of tin.

ACP Products and Processes

"Go to a Soldier's Head"

Millions of steel helmets owe the durability of their protective coating to DEOXIDINE. This acid-cleaner that made the all-steel automobile body possible removes oil and rust, eradicates rust-producers, and leaves an etched, passive surface that holds paint perfectly. It not only improves paint life, but simplifies processing.

DEOXIDINE not only serves in quantity production of helmets... numerous applications on many war products are being found every day in the treatment of steel, aluminum and dural for painting.

ACP Products and Processes . . . proved for more than 25 years . . . are helping Industry convert to production of many vital tools of war.

•

The following list is only an indication of the operations in which ACP can aid you:

RODINE—pickling inhibitor that saves steel and acid, prevents acid fumes and embrittlement. CUPRODINE—provides dense, bright copper coatings on steel by simple immersion (non-electrolytic). LITHOFORM—coats galvanized iron to hold paint. FLOSOL—an exceptional soldering flux for steel, brass, copper, tin, terne plate, zinc and galvanized iron. KEMICK—paint that holds to and protects metal surfaces subject to red heat.

With this as an indication, why not bring your problems of metal cleaning, treating and finishing to ACP?

AMERICAN CHEMICAL PAINT CO.
MAIN OFFICE AND WORKS
AMBLER · · · PENNA.
ACP
CHEMICALS ACP PROCESSES
DETROIT, MICH., 6335 Palmer Ave., E.
CANADIAN BRANCH
WALKERVILLE · · · ONT

Meetings and Expositions

AMERICAN PETROLEUM INSTITUTE, annual meeting. Chicago, Ill. November 9-13, 1942.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS, annual meeting. Cincinnati, Ohio. November 16-18, 1942.

NATIONAL CHEMICAL EXPOSITION. Chicago, Ill. November 24-29, 1942.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, annual meeting, New York, N. Y. November 30-December 4, 1942.

PLURAMELT...YOUNGSTER WITH A FUTURE

TODAY, Pluramelt products are entirely allocated for essential purposes. In fabricated form, they're serving in mess trays aboard ship—in field ranges—in kitchen and hospital equipment for the services—in the manufacture of synthetic rubber, high-octane gas, explosives, etc. The list includes both the single and double stainless-armored types.

In each case, of course, Pluramelt is used instead of *solid* stainless steel. The chief reason, therefore, is the very important matter of conservation. Pluramelt saves 60% to 80% of the vital chromium and nickel that solid stainless would consume for the same job.

But there are other prime considerations. Pluramelt in general fabricates easier than solid stainless steel. And, under any conditions of fabrication and subsequent service, it does not—*cannot*—come apart. Pluramelt is unique—a controlled composite steel with an *intermelted* bond that cannot be separated.

Do you want to know more about this stainless-armored steel that is so sure to bulk large in the peacetime manufacturing of the future? A new booklet, *"The Fabrication and Use of Pluramelt Stainless-Armored Steels"* is in preparation. Write us to reserve a copy for you.

Allegheny Ludlum
STEEL CORPORATION
GENERAL OFFICES: PITTSBURGH, PENNSYLVANIA

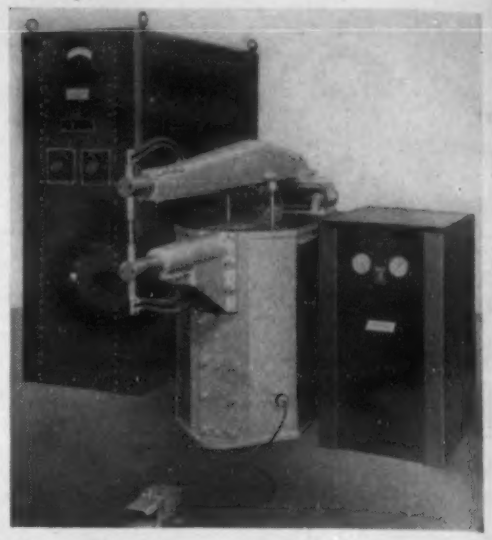
A-8676 . . . W & D

Refrigerated Resistance Welding Electrodes

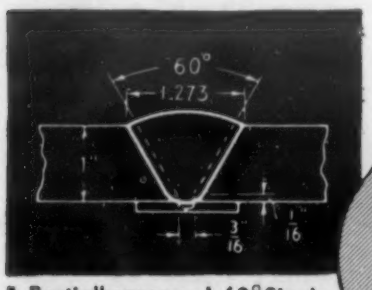
A new line of rocker arm welders for stored energy resistance welding of aluminum has been brought out by *Progressive Welder Co.*, E. Outer Drive, Detroit. These are available with the "Revers-O-Charge" capacitor discharge controls as well as with "Frostrode" refrigerating units for below-freezing welding.

In the Pedestal type welder the "Frostrode" unit is built into the base of the welding machine. Electrode refrigeration insures the maximum of heat dissipation at points where that heat is not wanted—where the electrodes contact the work. It is heat here that causes "pick-up" rapid mushrooming of electrodes, etc., which result in variable weld size, inconsistent weld quality and decreased production runs between point dressings.

With "Frostroded" Progressive welders there can be obtained the same production from three machines where five or six might otherwise be required. Again, lower tip temperatures can be obtained with 80 to 90 per cent less cooling water.

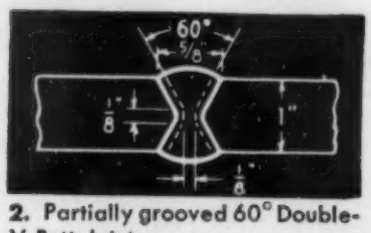


In the accompanying illustration, the "Revers-O-Charge" capacitor-discharge control is at the left, the "Frostrode" electrode refrigerator at the right.

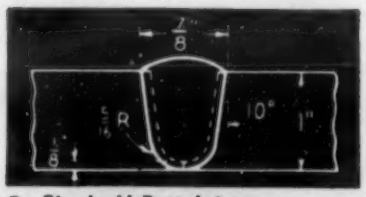


1. Partially grooved, 60° Single-V Butt joint with backing strip
Averages 4.56 lbs. electrodes per linear foot.

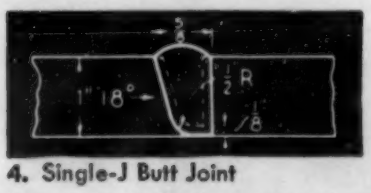
Same joint, 45° included angle and 3/8" gap
Averages 3.16 lbs. electrodes per linear foot.



2. Partially grooved 60° Double-V Butt Joint
Averages 3.02 lbs. electrodes per linear foot.



3. Single-U Butt Joint
Averages 3.85 lbs. electrodes per linear foot.



4. Single-J Butt Joint
Averages 2.70 lbs. electrodes per linear foot.

*Note: All of the above are for welding one inch plate. Figures are based on average conditions and are given only to illustrate the principle involved.

SELECTION OF PROPER JOINT HELPS CONSERVE ELECTRODES

WITH the critical shortage in electrodes, it is of vital importance that careful thought be given to employing joint designs that require minimum amounts of weld metal, bearing in mind, of course, the requirements of the job and all of the many variable factors, such as joint preparation, cleaning time, and welding procedure.

For instance, in butt welding one inch plate, original specifications might call for a partially grooved 60° Single-V Butt Joint (Fig. 1), requiring an average of 4.56 pounds of electrodes per foot of weld. Under certain circumstances, a Double-V Butt Joint (Fig. 2) would be just as practical and this joint would require only 3.02 pounds per foot, making a saving of more than 33% in pounds of electrodes consumed.

A study of the accompanying sketches shows other comparisons of the amounts of electrodes needed for various types of joints on butt welds.

We have prepared a complete set of charts showing the pounds of Murex electrodes required per linear foot of weld in common types of joints. Copies will be sent on request.

Specialists in welding for nearly 40 years. Manufacturers of Murex Electrodes for arc welding and of Thermit for repair and fabrication of heavy parts.

METAL & THERMIT CORPORATION
120 BROADWAY • NEW YORK, N. Y.

ALBANY • CHICAGO PITTSBURGH • SO. SAN FRANCISCO • TORONTO

MUREX
ARC WELDING ELECTRODES

Prize Contest in Metallizing

Metallizing Engineering Co., Inc. is offering a total of $650 in war bonds for details of maintenance and salvage procedures with the metal-spraying process. Prizes range: First, $250; second, $150; third, $100, with three prizes of $50 each. The contest closes December 15th. Complete information and entry forms are obtainable from *Metco News*, Metallizing Engineering Co., Inc., 21-07 Forty-first Ave., Long Island City, N. Y.

● Particularly suitable for lubrication of mechanisms operating at high temperature or where permanent or semi-permanent lubrication is to be provided by the colloidal graphite is a new standard graphite dispersion sponsored by *Acheson Colloids Corp.*, Port Huron, Mich. Unusual flexibility is claimed. Among major uses are those involving stamping dies, clutch plates and colloidal impregnation of fabrics.

Another "Largest Drawing Press"

Following publication of an item in these columns in our September 1942 issue, describing "the largest drawing (die stamping) press in the world, according to its makers, Hydraulic Press & Engineering Co.," a letter was received from *E. W. Bliss Co.*, Brooklyn, stating it had made even larger presses.

The press described in these columns in September weighs 250 tons. However, the Bliss Company writes that in 1938 they constructed a No. 398-144 double crank triple action drawing press, weighing 362½ tons. Total pressure develops 2,100 tons, with width between uprights 144 in.

In 1936 Bliss built the Toledo No. 397-180 triple action drawing press, weighing 387½ tons; total pressure 2,000 tons; width between uprights 180 in.

an EPISODE FOR THE MAN WITH War Time Heat Treating Problems

200,000,000 WANTED
TELEGRAM
CAN YOU HEAT TREAT 12,000,000 37 M.M. SHOT?
TELEGRAM
SEND ME HEAT TREATING INFORMATION
contents
REPLENISHMENT CHART OF DUPONT CARBURIZING SALT BATH
yours for the Asking
molten salt baths
for heat treatment and case hardening of steel
ELECTROCHEMICALS DEPARTMENT
E. I. DU PONT DE NEMOURS & CO. (INC.)
DUPONT

E. I. DU PONT DE NEMOURS & CO. (INC.)
ELECTROCHEMICALS DEPARTMENT
Wilmington, Delaware

CYANIDES AND SALTS FOR HEAT TREATING

Thomas H. Miller, mining engineer and metallurgist, has been named chief of the Metals Economics Div., Bureau of Mines, having been assistant chief. He has been with the Bureau since 1928.

Lowell L. Henkel, metallurgist, research engineer and chemist, Interlake Iron Corp., Chicago, has joined WPB, Chicago, as administrative aid, Technical Development Section, Production Branch.

Hans R. Stephan has been made assistant metallurgist, Allis-Chalmers Mfg. Co., Milwaukee.

Maurice G. Jewett, formerly chief metallurgist and engineer, Chain Belt Co., Milwaukee, has been commissioned a lieutenant-colonel in the Army.

Samuel R. Robinson, foundry metallurgist, Otis Steel Co., has become works manager, Valley Steel Castings Co., Bay City, Mich.

Edwin H. Brown, vice-president in charge of engineering, Allis-Chalmers Corp., Milwaukee, has been appointed assistant chief of the Iron and Steel Branch, WPB. He has been with the Allis-Chalmers Corp. since 1906.

Charles G. Maier, research metallurgist for nearly 20 years with the U. S. Bureau of Mines, has been named to the supervisory staff of Battelle Memorial Institute, Columbus, Ohio. Mr. Maier was previously supervising research engineer of the Pacific Experiment Station, U. S. Bureau of Mines, Berkeley, Cal. Earlier he held industrial positions with the Carborundum Co., Niagara Falls, N. Y. and the Phelps Dodge Corp., New York.

Robert C. Sessions, of the consulting engineering firm of Sessions & Sessions, Cleveland, has been appointed chief engineer of the Brown Fintube Co., Elyria, Ohio. For some time he had been in charge of the engineering and experimental division of Steel & Tubes, Inc.

Perry R. Cassidy, former executive assistant, Babcock & Wilcox Co., has become a lieutenant-colonel in the Engineer Corps, U. S. Army. He began his service with Babcock & Wilcox in 1916, and was appointed a vice president of Fuller Lehigh Co. in 1928. He is a member of several technical societies, an author of several technical papers, and is a member of the technical advisory committee on alloy steel plate, WPB.

Dr. Charles F. Burgess, inventor of the battery that bears his name, has been awarded the Edward Goodrich Acheson medal and $1000 prize by the Electrochemical Society, the highest award in that field. Dr. Burgess is the inventor of numerous and highly diversified products and processes, including electrolytic iron.

An associate director and two new assistant directors of the Aluminum Research Laboratories of the Aluminum Co. of America have been named by Dr. Francis C. Frary, director. *Herman E. Bakken,* who has been assistant director of research, is now associate director. *E. H. Dix, Jr.,* chief metallurgist, and *R. L. Templin,* chief engineer of tests of the Aluminum Co., are assistant directors.

D. L. Immel has been promoted to assistant plant superintendent at the Copperweld Steel Co.'s. Warren, Ohio, plant.

Herbert J. Burgess has been appointed general superintendent in charge of all manufacturing at the Westinghouse Electric & Mfg. Co.'s East Springfield plant. As a skilled toolmaker, he helped Westinghouse produce rifles and machine guns during the first World War. He joined the company in 1917, became supervisor of cost reduction in 1927, and in 1935 became foreman of tool design and tool manufacturing.

ROTOBLAST

"CLEANS FAST"!

IF YOU NEED PRODUCTION

PANGBORN AIRLESS EQUIPMENT *DELIVERS IT!*

Day and night — PANGBORN Blast Cleaning Equipment is ON ACTIVE DUTY! The efficiency of every unit we make is dedicated to the one fact that WE HAVE A WAR TO WIN — and only the continuous production of MORE PRODUCTS, IN LESS TIME — WITH LESS WASTE — will win it! ROTOBLAST Barrels, Tables and Special Cabinets are doing a record smashing job in cleaning shells, bombs, all kinds of castings, heat-treated parts, forgings, armor plate, tank parts, etc. We can help you too! Write or wire.

Send for ROTOBLAST Barrel and Table Bulletins

PANGBORN

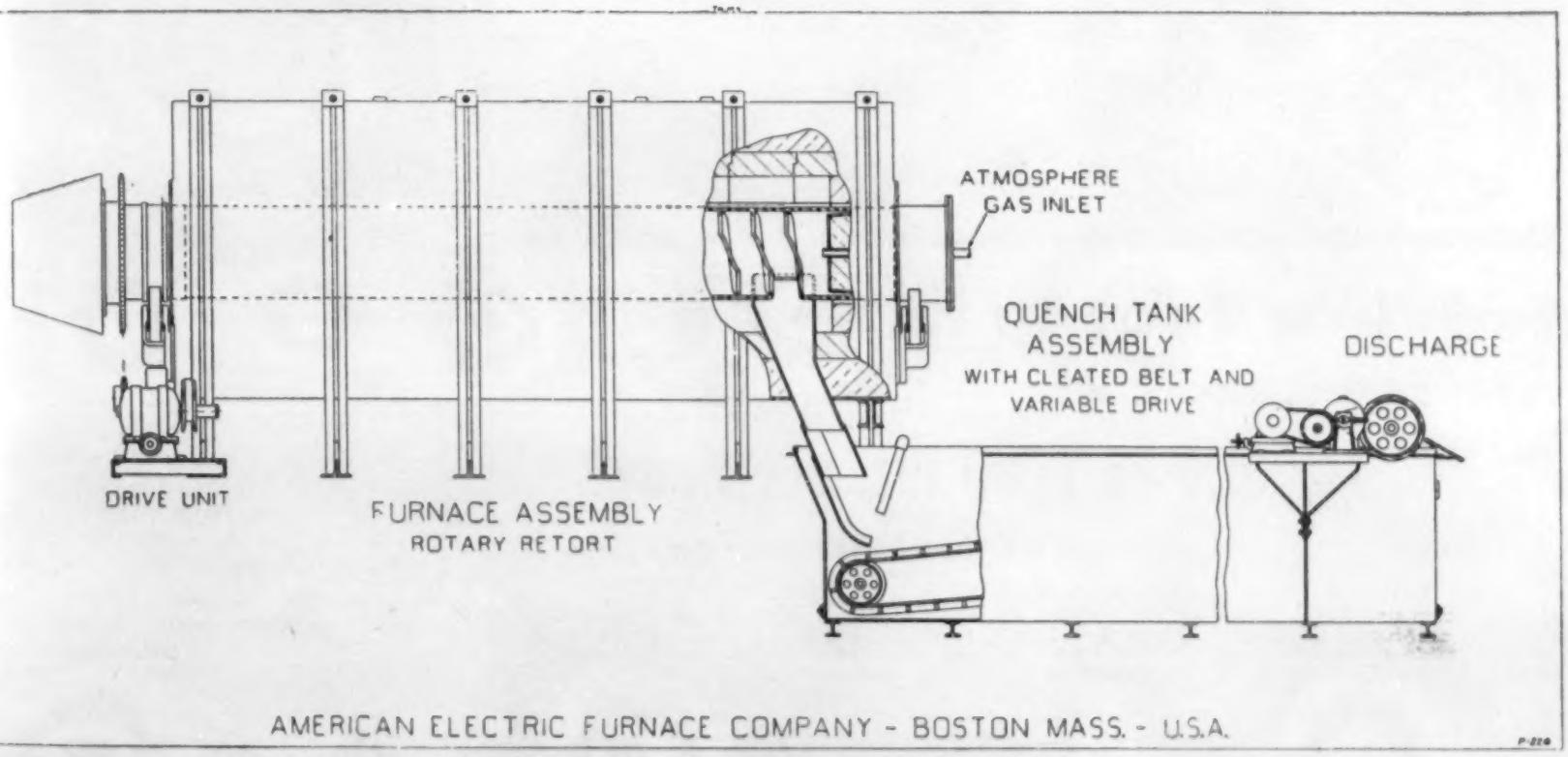
WORLD'S LARGEST MANUFACTURER OF DUST COLLECTING AND BLAST CLEANING EQUIPMENT

PANGBORN CORPORATION . . . HAGERSTOWN, MARYLAND

Bullet Cores

Investigate the time and labor saving features in the heat treatment of bullet cores with the

AMERICAN ELECTRIC CORE HARDENING FURNACE



CAPACITY 1200 POUNDS PER HOUR

American Electric Furnace Company

29 VON HILLERN ST. ★ BOSTON, MASS., U. S. A.

Industrial Furnaces for All Purposes

Tools for Interrupted Cuts

Standardized designs of "shear type" tools to facilitate machining of steel parts where cuts are of the interrupted type and on large machines primarily have been brought out by *Carboloy Co., Inc.*, Detroit. These tools have a large negative back rake, which results in a shaving form of cut when used for turning or facing.

In interrupted cuts, the impact load on the tool does not come at the end of the tip but farther back. Entry of the cutting edge after interruptions is gradual, starting at the contact point back from the tip, working forward to the tool's tip.

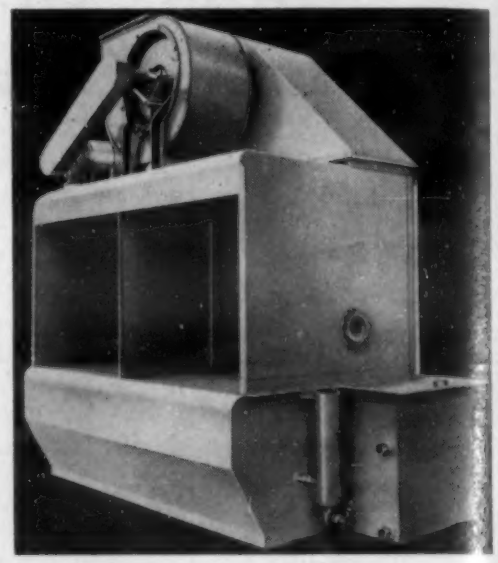
These tools have done much machining of the newer tough alloy steels, from which experience standardization of optimum shapes and dimensions has been accomplished. There are four basic sizes, each left- and right-handed varieties. All have a negative back-rake of 40 deg. Relief angles are finish-ground. Rear corners of tips project slightly above tops of shanks.

Dust Collector Is Used for Metals

Further developments have been made and patented in the wet dust collector, Hydro-Whirl, used a great deal now in work around magnesium, and made by *Industrial Sheet Metal Works*, Detroit.

Instead of being made of steel, the bench-high grating of the work compartment is made of hardwood, thus avoiding sparks if struck by a grinding wheel or tool and eliminating fire hazard. Booth sections are lined with Masonite.

Water in the tank below the grating is kept at uniform height automatically. The working principle is that dust is trapped and brought into the tank where it becomes a harmless element, later burned or buried. Chief mechanism is a rotating shaft on which is centered a series of discs. In a horizontal plane, it throws water



into the baffled section where the dust is whirled out of the air stream.

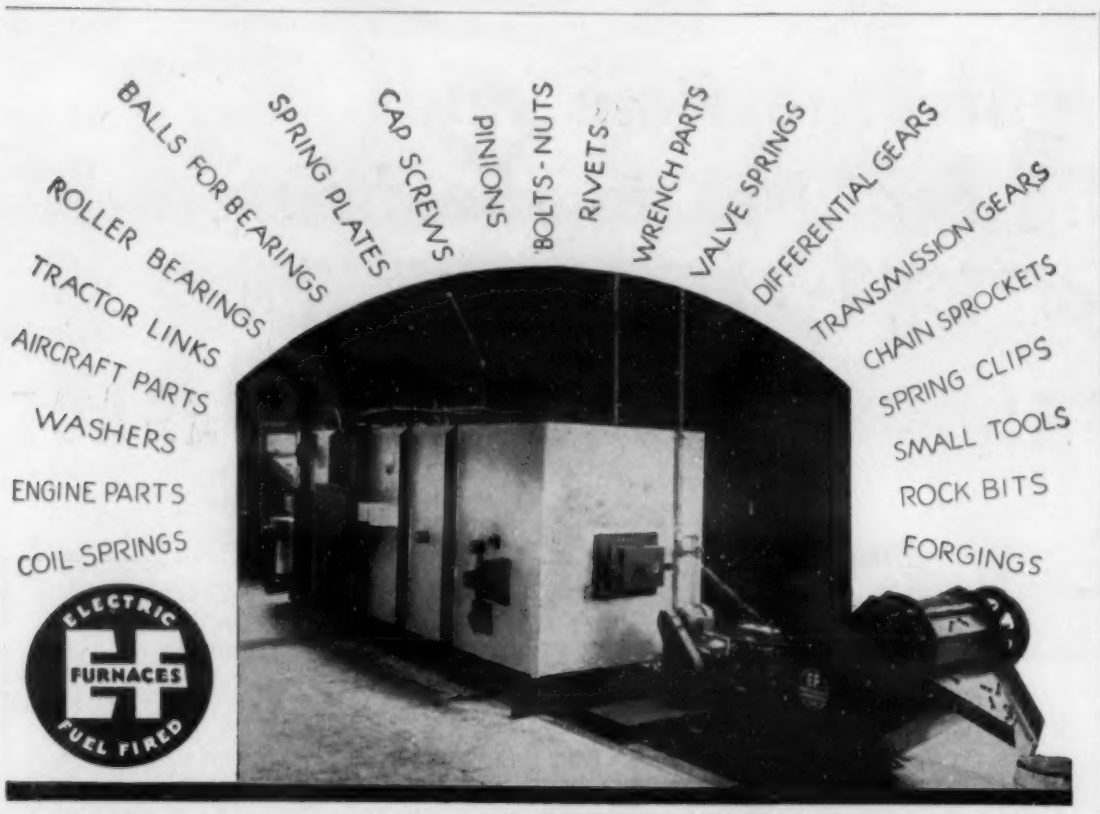
The equipment is effective with several metals.

• Assisting in cutting tapers on a lathe, perhaps to within 0.0001 in., one company has installed a magnifying lens of "Lucite," a methyl methacrylate resin. This lens also keeps out grease and dirt and reduces breakage and replacement costs. Lucite is produced by *E. I. duPont de Nemours & Co., Inc.*, Wilmington, Del.

Electric Furnaces Redesigned for Scrap

To handle the peculiar type of lighter scrap now being turned into the steel mills, the *Pittsburgh Lectromelt Furnace Corp.*, 135 32nd St., Pittsburgh, has improved the design of some of their smaller size electric furnaces. Side plates have been elongated to increase volumetric scrap capacity and maintain rated capacity of heats.

In their 10-ton furnace, the side walls were deepened to allow an increase of 25 per cent in scrap capacity, due to the changed character of scrap, with its large proportion of punched out sheets, shell turnings, etc., often not baled, in the place of the usual heavy railroad scrap.



For Hardening Machine Gun Cartridge Clips

and Miscellaneous Other Products

---300 to 1700 lbs. per Hour

. . . Investigate E F Chain Belt Conveyor Type Furnaces

E F Continuous Chain Belt Conveyor Type Furnaces are handling all kinds of products ranging in sizes from small springs and machine gun cartridge clips up to large crawler links for tanks and tractors. Hundreds of these furnaces are in operation, handling such products as listed above.

The material is loaded directly onto rugged heat resisting cast link belt conveyors. Without further attention, it is carried through the furnace, uniformly heated to the proper temperature and automatically discharged through a sealed chute to the quenching medium or directly from the furnace as desired. The chain belt conveyor returns within the furnace without cooling—no pans or trays are used in the furnace—100% net material.

These furnaces are built for oil, gas or electric heat in five standard sizes with capacities ranging from 300 to 1700 lbs. per hour. Larger or smaller sizes can also be furnished. They are also designed for using special protective atmospheres for scale-free heat treating and hardening without decarburization.

The hundreds of installations in operation, handling all kinds of material, have proven them the most satisfactory and dependable general purpose heat treating machines built for the uniform, economical, production heat treatment of miscellaneous small and medium sized parts and products.
The Chain Belt Conveyor Furnace is only one of the numerous types of production furnaces we build for various heat treating purposes.

Tank armor castings, shell forgings, cartridge cases, bomb and gun parts, aircraft and aircraft engine parts, and many other allied products are being uniformly treated in outstanding production furnaces built by the Electric Furnace Company, Salem, Ohio. We specialize in designing and building production furnaces.

Send for circulars showing these and other types

The Electric Furnace Co., Salem, Ohio

Gas Fired, Oil Fired and Electric Furnaces---For Any Process, Product or Production

New PAGE ELECTRODE FOR ARMOR WELDING HELPS GET TANKS INTO ACTION!

A new electrode for welding armor was developed exclusively by **PAGE** *to cooperate with the change-over to welded tank production. It met all ballistic tests on plates submitted to the Army Ordnance Department by the tank manufacturers—and then went into action, having a real part in the great records that since have been set on welded tank production lines.*

It is worthwhile to note that, in spite of the pressure for speed, tank welders have been well schooled in technique that wastes no electrode—gets maximum strength with the use of no unnecessary metal in the weld—uses every electrode right down to the holder. All users of welding rod would do well to insist on their men observing such economy today.

PAGE WELDING ELECTRODES

PAGE STEEL AND WIRE DIVISION
Monessen, Pa., Atlanta, Chicago, New York, Pittsburgh, San Francisco

AMERICAN CHAIN & CABLE COMPANY, INC.
BRIDGEPORT, CONNECTICUT

In Business for Your Safety

Photo by U. S. Army Signal Corps

Tool Bits for Hard, Tough Steels

A new line of tool bits for machining hard, tough steel and other copper or aluminum alloys has been made available by *Black Drill Co.*, Cleveland. They are made of the same metal as "Hardsteel" drills and reamers.

In tool bits this metal has greater shock resistance than most cast or cemented tools and has higher heat resistance. It gives complete satisfaction when used on abrasive copper, brass, bronze and aluminum alloys.

Cases on record show that cuts per grind increased 400 to 500 per cent when these tool bits replaced high speed tools.

Compressed Air in Hardness Testing

A compressed air application, used as an accessory to the Rockwell hardness gage, is reported to have speeded bomber part testing by *Brewster Aeronautical Corp.* engineers by 400 per cent. The device, called a Comparator, comprises a table-mounted yoke that supports a penetrator over an anvil, the die end of which is the same size as that used in the Rockwell gage.

The anvil moves up against the penetrator under pressure of a piston worked by compressed air under 100 lbs. per sq. in. The tested piece is pressed against

the spherical die with pressure enough to indent the surface. A Starrett dial indicator shows depth of indentation. A pedal air valve frees both hands of the operator. The comparator is calibrated by choosing a test piece of correct hardness.

● Moisture is removed from the air below 32 deg. F. without causing formation of ice on cutting-oil and lubricating-oil coolers by the Niagara "No Frost" method, which employs a special non-freezing liquid continuously reconcentrated in a concentrator especially designed. The equipment is manufactured by the *Niagara Blower Co.*, 6 East 45th St., New York.

A-C Welder for Heavier Metals

Designed to increase the efficiency and step up the speed of welding heavier, thicker metals is the new alternating current welder of the *Allis-Chalmers Mfg. Co.*, Milwaukee.

Transformer and reactor are built as an integral unit. The reactor coils surround the air gap, eliminating magnetic leakage. This provides continuous control from 35 to 250 amperes — a safe, high, open circuit voltage at low current where a-c welding was previously most difficult, and a lower open circuit voltage at higher current where efficiency and power factor are all-important.

This welder supplements the Allis-Chalmers' Weld-O-Tron d-c unit, which welds as thin as 32 gage and consumes current as low as 5 amps. The two welders cover a range of 5 to over 600 amps.

● Certain parts of a Wheelabrator airless abrasive blast cleaning unit that are subjected to special abrasive wear bear the insignia "AR," and are made of special alloy steel. Such a part can be returned to the maker, *American Foundry Equipment Co.*, Mishawaka, Ind., when badly worn, for rebate at 10c per lb. This plan not only helps conserve metals, but also helps keep scrap segregated, since "AR" parts contain chromium and molybdenum.

When General Doolittle and his squadrons made their surprise raid over Tokio, they carried a message of things to come—the only type message Japs can understand! Naturally we are proud that the equipment of these planes contained wire made by Wilbur B. Driver Co. The entire facilities of our plant are devoted to producing, as never before, special alloys* (including beryllium-copper) for all war purposes. Consult us for your requirements.

*Available in rod, wire, ribbon, and strip—both hot and cold rolled.

WILBUR B. DRIVER CO.
NEWARK, NEW JERSEY

THE UNITED STATES NAVY, *in 1875 gave its first steel ordnance order to an American manufacturer,—to Midvale.*

Those three-inch howitzers, formidable enough in those early days, would be rather futile now. It is interesting to record that, at the same time, Midvale made, voluntarily, some *extra* howitzers, on which were carried out experiments in heat treatment with noteworthy results. That Midvale policy, of considering each new order, each new problem, an opportunity for further development has resulted in a knowledge of steel and its alloys that has pre-solved many an industrial problem even before that problem arose. That knowledge is serving the nation well today, will be equally ready to serve it tomorrow.

1867 75TH ANNIVERSARY 1942

THE MIDVALE COMPANY • NICETOWN • PHILADELPHIA, PA.

OFFICES: New York • Chicago • Pittsburgh • Washington • Cleveland • San Francisco

MIDVALE

Tool Engineers Choose Textbooks

Training of tool engineers for war production is being handicapped seriously by lack of adequate textbook material, it was revealed at the War Production Conference of the American Society of Tool Engineers at Springfield, Mass., in October. After reviewing more than 100 technical books on various essential tool engineering subjects, only nine suitable for various required training courses have so far been found by the Education and Emergency Training Committee.

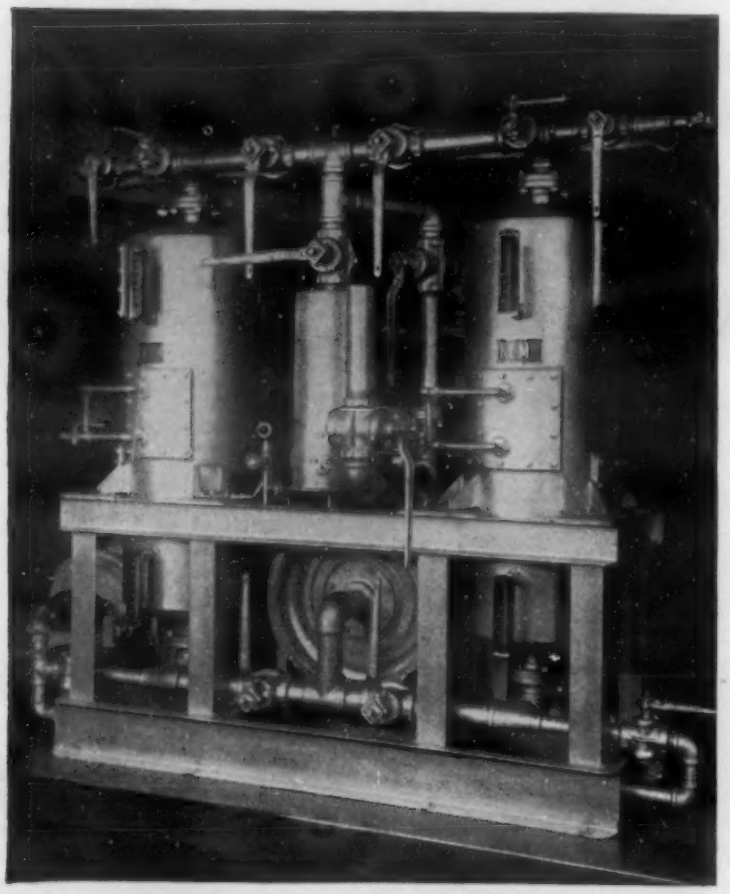
In machine design, mechanics and other subjects taught in colleges, there are many textbooks, but on jig and fixture design, press tools, die making, etc., the books are mainly for reference for the engineer already in the field.

"Tool Design" by C. B. Cole, published last year by the American Technical Society, has been selected for the course on jig and fixture design. "Press Working of Metals", by C. W. Hinman, has been selected on sheet metal and design.

On foundry practice and pattern making the committee has chosen "Metal Casting," by Harry L. Campbell (John Wiley and Sons, 1936). "Fundamentals of Machine Design" by Norman, Ault and Zarobsky (The MacMillan Co., 1930) has been named on that subject.

For courses in applied mechanics, "Analytical Mechanics for Engineers", by Seeley and Ensign (John Wiley and Sons, 1941) and "Strength of Materials", by J. W. Breneman (McGraw-Hill, 1941) have so far been recommended.

● Silver-ply stainless-clad steel kettles are made by Groen Mfg. Co., Inc., Chicago, from steel furnished by the *Jessop Steel Co.*, Washington, Pa. The entire inside and cover are protected by a stainless steel surface, having all the desirable features of solid stainless steel kettles, states the maker. A 20 per cent clad sheet of clad steel saves four fifths of the stainless steel of a solid piece.



for

DRY

ANNEALING ATMOSPHERES

KEMP SILICA GEL DEHYDRATORS guarantee the *exact* degree of dryness you need in *your* annealing atmospheres.

Designed by gas equipment engineers; and proven by an impressive record of dependable and economical operation in plants demanding constant and exact drying of annealing atmospheres.

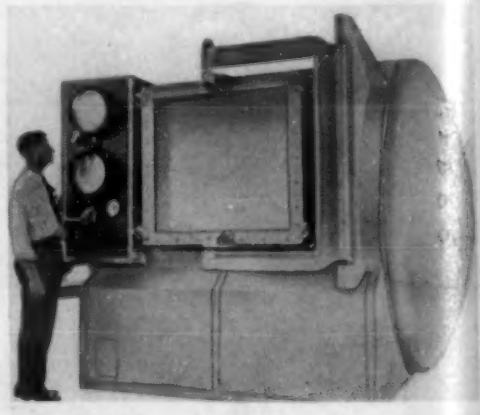
Write **The C. M. Kemp Mfg. Company, 405 East Oliver Street, Baltimore, Maryland—ask for Dryer Bulletin.**

STANDARD UNITS BUILT TO GIVE:
Capacities: 10 to 100,000 c.f.m.
Pressures: Atmospheric to 2500 lbs. per square inch
Adsorbent: Silica Gel, high capacity, long life
Activation: By gas, electricity, or steam, as desired
Types: Single or twin towers for intermittent or continuous operation

KEMP of BALTIMORE

Stratosphere Testing of Parts

To test the mechanical parts of aircraft and radio for their behavior in high altitudes, a stratosphere chamber that operates between temperatures of +200 deg. F. and —75 deg. F. has been developed by *Kold-Hold Mfg. Co.*, Lansing, Mich.



Internal pressure variation is from ambient at the location of the unit to 3 in. of mercury absolute.

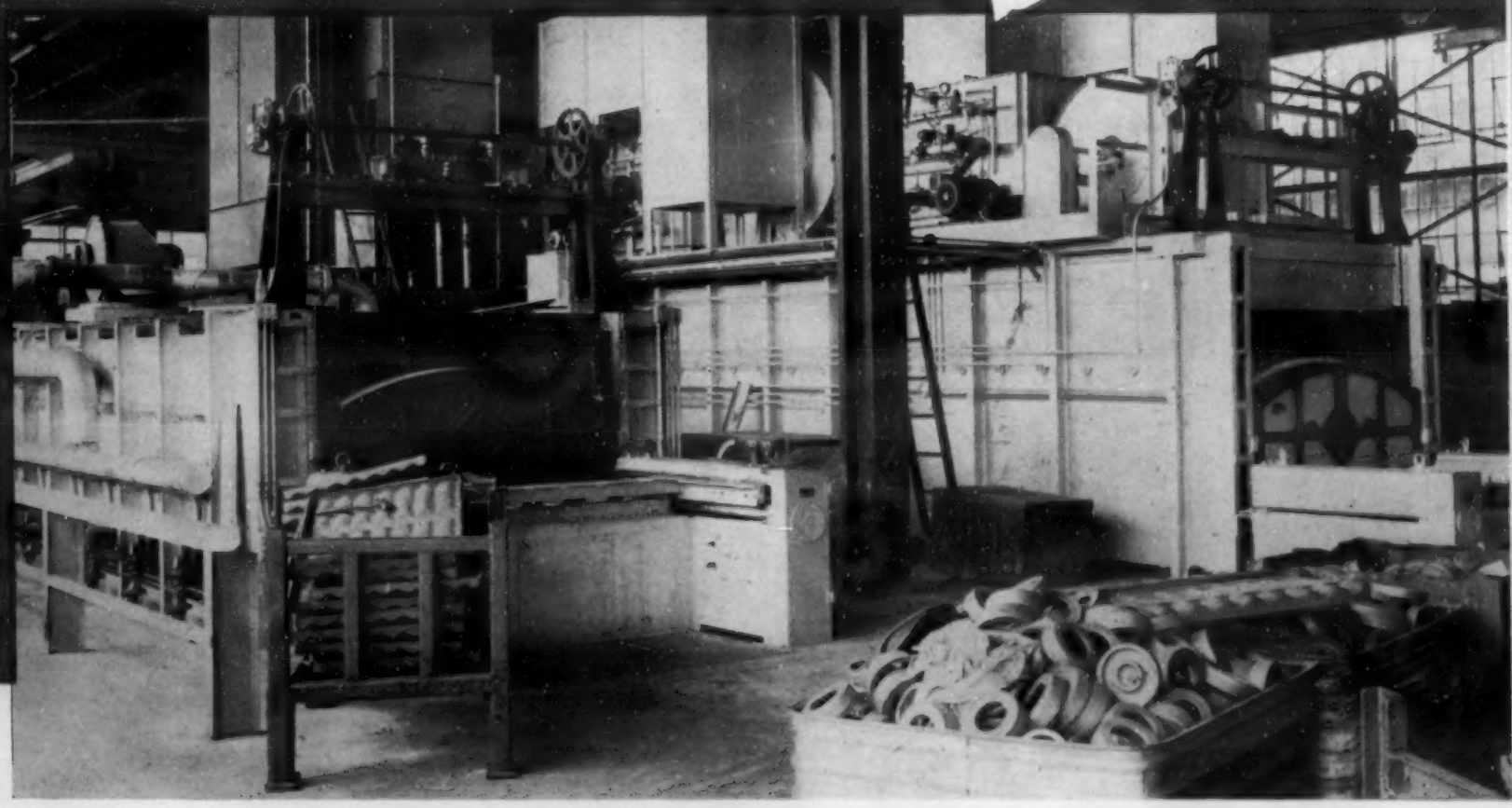
The chamber has an interior volume of 245 cu. ft., uses "Freon-12" as refrigerant. Heat acceptance from the chamber is by forced convection through coils designed for low temperature work, each coil capable of accepting a minimum of 200 B.t.u. per degree at —75 deg. F. and 3 in. mercury pressure.

Humidity control is from 25 to 95 per cent, relative to all temperatures above +40 deg. F., or at a fixed bottom temperature of +32 deg. F.

• A new feature has been added to the steel-grip finger guard, made by *Industrial Gloves Co.*, Danville, Ill. It is the added leather section over the back of the finger, at the tip end. It is good for punch press work, sanding, burring, grinding, buffing, assembly, etc.

These HAGAN FURNACES HARDEN, QUENCH and DRAW

15 Airplane CRANKCASE FORGINGS per HOUR



OPERATING SPECIFICATIONS

Hardening 1575° F.
Quenching 130° F.
Drawing 1240° F.

(All equipment operating on a four-minute cycle)

One of many important war production installations, these two Hagan furnaces with quenching mechanism heat, quench and draw fifteen airplane crankcase forgings weighing in excess of 3000 pounds per hour. Full flexibility and complete heat control of parts are typical Hagan features that are helping this important arsenal of democracy to speed their production.

"VICTORY PRODUCTS"
Treated in HAGAN Furnaces

Aircraft Crankcases . . Connecting Rods . . Propellers . . Hub Spiders . . Steering Knuckles . . Cam Shafts . . Steering Arms . . Crankshafts . . Gun Carriage Parts . . Landing Gear Parts and other numerous miscellaneous ordnance parts.

GEORGE J. HAGAN CO.

PITTSBURGH, PA.

Detroit • Chicago • Los Angeles • San Francisco

Electric Arc Furnace Control

What is described as "revolutionary" new electric arc furnace control, which will increase efficiency of electric furnace steel production in steel plants and foundries, is announced by *Allis-Chalmers Mfg. Co.*, Milwaukee. The "Regulex" exciter has been applied for sensitive control on temper pass and reversing mills. Extreme accuracy is claimed from quick reversing and smooth acceleration.

It controls arc energy to a constant quantity without the use of contact-making devices. Control field windings that measure arc current and volts are part of the element. The electrode is raised or lowered, as required.

Special Furnace Built Speedily

Forty-nine days from idea to plant operation is the speed record set by the *Johnson Gas Appliance Co.*, Cedar Rapids, Iowa, in producing a special large heat-treating furnace for one of the nation's busiest war plants. The inside combustion chamber is 36 in. wide, 30 in. high and 60 in. long. It is lined with 5½ in. insulation and faced with 4½ in. insulating refractory.

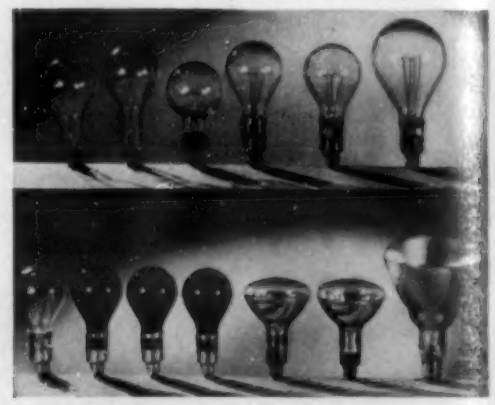
Among the unusual features are the electrically-operated door that raises in 5 sec. and stops automatically; proportioning-type control that automatically regulates furnace temperature and stack damper position; and push-button electric ignition

that lights burners with complete safety. The furnace produces 2000 deg. F., and maintains this constantly.

Infra-Red Baking Lamps

A new line of infra-red heat lamps for baking and drying metal products, etc., features the M-type tungsten filament for uniform heat distribution. They have their bases reinforced with asbestos-lined mechanical straps.

The line includes six clear types, three ruby types and four reflector types. The



reflector types have built-in reflector linings of pure silver sealed inside the bulbs for protection against dimming and tarnishing by fumes or dirt.

Average burning life of all is over 6,000 hours. Advantages claimed for infra-red are: speed, ease of operation, and economy. Users report up to 95 per cent faster baking and drying time than with older baking systems. The manufacturers are the *Wabash Appliance Corp.*, 345 Carroll St., Brooklyn.

● A new full-electronic timer and control for seam, also spot, welders has been produced by *Weltronic Corp.*, E. Outer Drive, Detroit. For spot welding machines this new model 40 timer provides both single and pulsation type welding controls. It starts and stops current flow at the zero point of the current wave, while current duration is adjustable to the exact number of cycles desired.

DEPTHS TO 0.150" SPEED QUALITY

NEW CARBURIZING MEDIUM

PROVIDES IMPROVED DEEP-CASE RESULTS

ECONOMY UNIFORMITY SIMPLICITY

Aerocarb* DEEP-CASE carburizing compounds No. 13 and No. 40 provide a rate of penetration equivalent to gas carburizing and more rapid than pack carburizing. The case and operating characteristics are as follows:

CASE CHARACTERISTICS

1 The case produced is similar in composition to the usual gas and pack carburized cases, but in addition contains a small amount of nitrogen in surface layer.

2 Eutectoid plus hypereutectoid zones comprise roughly 40% of the total case. Approximately 75% of the total case is 0.40% carbon or higher.

3 A hardness of Rockwell C-67 can be developed on SAE 1020 steel.

OPERATING CHARACTERISTICS

1 This cyanide deep-case bath is designed for operating temperatures of 1700°F to 1750°F.

2 The rate of cyanide loss at temperatures of 1700°F to 1750°F is approximately ⅛ of 1.0% per hour.

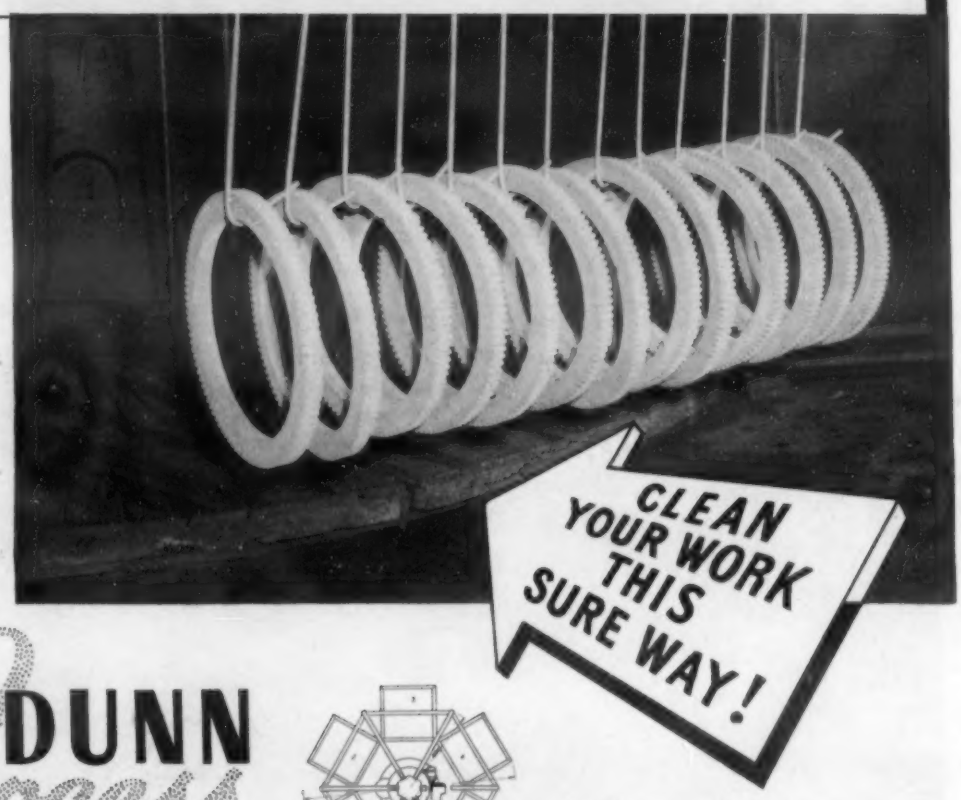
3 The molten density of the bath at 1700°F is 136 pounds per cubic foot.

When considering installation of new case hardening equipment, as much as 50% can be saved on the initial investment by setting up for salt bath treatment.

If your requirements call for case depths of 0.001" to 0.150" Cyanamid Deep Case Aerocase* Aerocarb sodium cyanide or one of our sodium cyanide case hardening compounds, 30%, 45%, 75%, these products can be relied upon to provide satisfactory results at low cost.

AMERICAN CYANAMID
& CHEMICAL CORPORATION
A Unit of American Cyanamid Company
30 ROCKEFELLER PLAZA · NEW YORK, N. Y.
* Reg. U. S. Pat. Off.

Want FASTER, BETTER DESCALING?



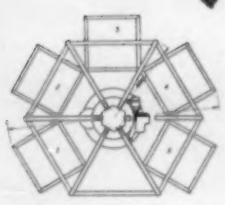
SPEED up your war production and do a better job for Uncle Sam by using the Bullard-Dunn Process. Observe what this process does: Removes grease and scale *without etching or dimensional changes* and leaves both *exposed surfaces and recesses chemically clean* for such subsequent operations as electroplating, Parco Lubrizing, blackening, grinding, or final assembly.

Bullard-Dunn is dependable, rapid and economical. All installations, manually-operated or conveyorized, are engineered to fit the job.

Write for bulletin today and send samples too, if available.

BULLARD-DUNN PROCESS
DIVISION OF THE BULLARD COMPANY
BRIDGEPORT, CONNECTICUT U. S. A.

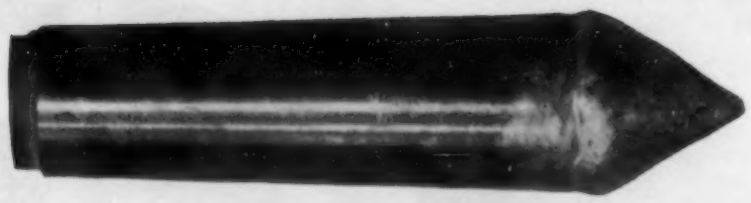
BULLARD-DUNN *Process*



← *Diagram of typical conveyorized installation.*

CENTERS LAST LONGER when HARD FACED with

COLMONOY
Hard Surfacing Alloys and Overlay Metals



COLMONOY faced centers last from 3 to 5 times as long as centers of high speed steel. The unground centers pictured here—unretouched—have been coated with COLMONOY No. 6. Note the uniformity of these oxy-acetylene welding applications.

The extremely high wear resistance of the hard surface of COLOMONY overlays will protect all vital wearing parts in the machine tool industry. Mild steel parts coated with COLOMONY alloys wear from 3 to 10 times as long as new parts made of high alloy steel.

WRITE TODAY

Learn about COLMONOY and what it is doing to *conserve vital metals.*

WALL-COLMONOY CORP.

720 FISHER BLDG., DETROIT, MICH.

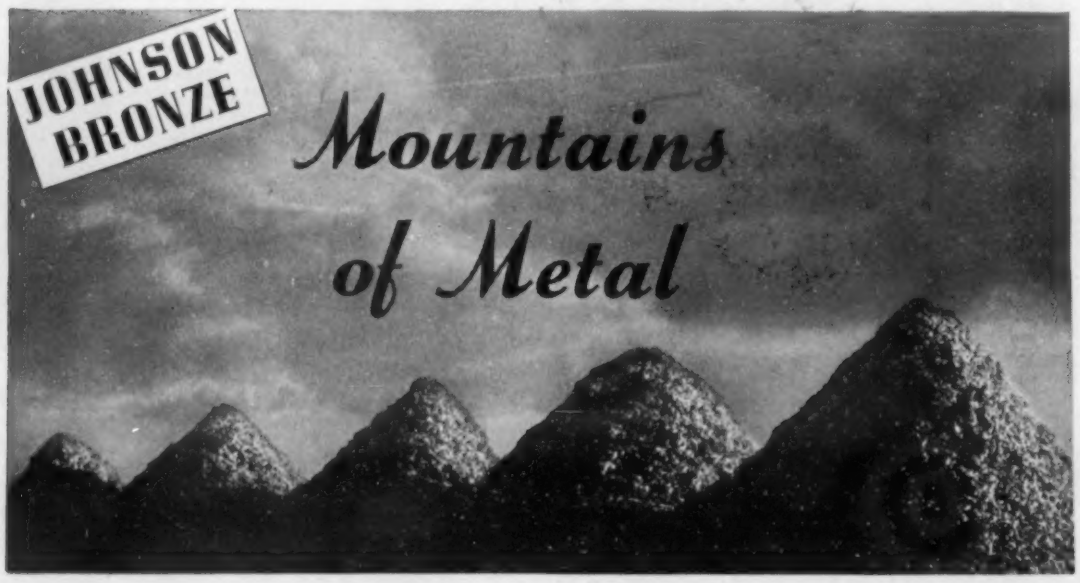
Branch Offices at NEW YORK CITY, BLASDELL, N. Y., CHICAGO, TULSA, WHITTIER, CALIF. OTHER BRANCHES IN CANADA.

• To eliminate a vast amount of special tool designing by carbide tool users and to speed deliveries, *Carboloy Co., Inc.*, Detroit, announces a series of "design standards." They eliminate the time normally required to prepare design drawings, figure quotations, prepare working drawings, and hand forming of special samples. It was found that many special tools were quite similar in design and application, differing only in minor dimensions, etc. By eliminating minor variations, most special tools and blanks could be reduced to a few "standard" designs.

Hitler Is Thumbing His Way to Hell

The accompanying photo suggests many wisecracks for patriotic Americans. Since the sign was fabricated by arc welding, a "hot time for Hitler" is suggested, borrowed from the heat in the process. "Putting up a scrappy fight against Hitler" might be suggested by a high school freshman.

This ferrous handiwork was placed in the front office window of the Kansas City office of the *Lincoln Electric Co.*, Cleveland. Even the message was arc welded on the plate from scrap stub ends of electrode.



that could help WIN the WAR

Every time you purchase Bearing Bronze in the "rough," you buy at least 25% more metal than necessary. Quality bearing bronze contains copper, tin and lead . . . metals that are vital to our war effort. When your purchases amount to tons, you actually remove mountains of metal from the active market.

You can easily avoid this waste . . . get a higher quality product . . . save many hours of machine time by specifying Johnson UNIVERSAL Bronze. Every Johnson bar is completely machined—I. D.—O. D.—ENDS. Our range of over 350 stock sizes enables you to buy according to your needs. Why not start today to help conserve metal? Your local Johnson Distributor can give you excellent service. His name will be found in your telephone book.

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Potassium Silicate for Welding Rods

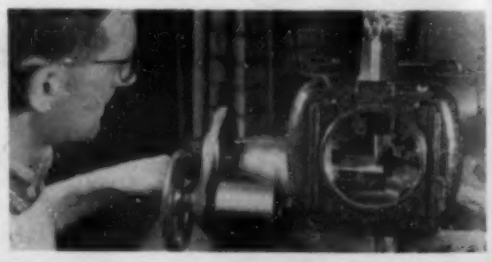
Potassium silicate is used extensively by manufacturers of welding rods. One of the most important processes in the welding rod industry is the extrusion method of production which employs potassium silicate of correctly controlled viscosity. Two new grades of potassium silicate have been announced by the *Philadelphia Quartz Co.*, 121 South Third St., Philadelphia—Kasil. Nos. 2 and 6.

The No. 2 is a 32 deg. Baume product with the molecular ratio of 1:3.92 and the No. 6 is 40.5 deg. Baume, ratio 1:3.29. Both are offered in steel returnable drums, or in single trip packages. Another use is for carbon electrodes.

• Hyper-Reset is a new control function, available in the newly-designed Model 60 Stabilog controller, for application where process-lag is considerable, manufactured by the *Foxboro Co.*, Foxboro, Mass. Tests have shown that, following an upset, in one-quarter of the time and with only one-half the upset effect, the Hyper-Reset, consistently re-established process stabilization, as compared with a similar controller.

Magnifying Glasses Aid Precision

Four new models of "Super Sight," adapted to close inspection, small parts assembly and precision machining, have been brought out by *Boyer-Campbell Co.*, 6540 Antoine St., Detroit. An interesting feature is the versatility of adjustment of the lens in a bracket so that the lens, or lenses, are where wanted, unhampering the worker.



In the accompanying photograph, the application to precision thread grinding is illustrated.

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Agency—Buchen Co.

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Agency—Richard Thorndike

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Illinois Clay Products Co. 929

★ Illinois Testing Laboratories, Inc. .. 936

★ Indium Corp. of America 958
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Agency—Cory Snow, Inc.

★ Riehle Testing Machine Division ... 978
Agency—L. W. Ramsey Co.

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Agency—Park City Advertising Agency, Inc.

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Agency—Essig Company, Ltd.

Union Carbide and Carbon Co. ... 861

Upton Electric Furnace Division ... 999
Agency—Alfred B. Hard Co.

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Wilson Mechanical Instrument Co. 974

Wilson Co., H. A. 985
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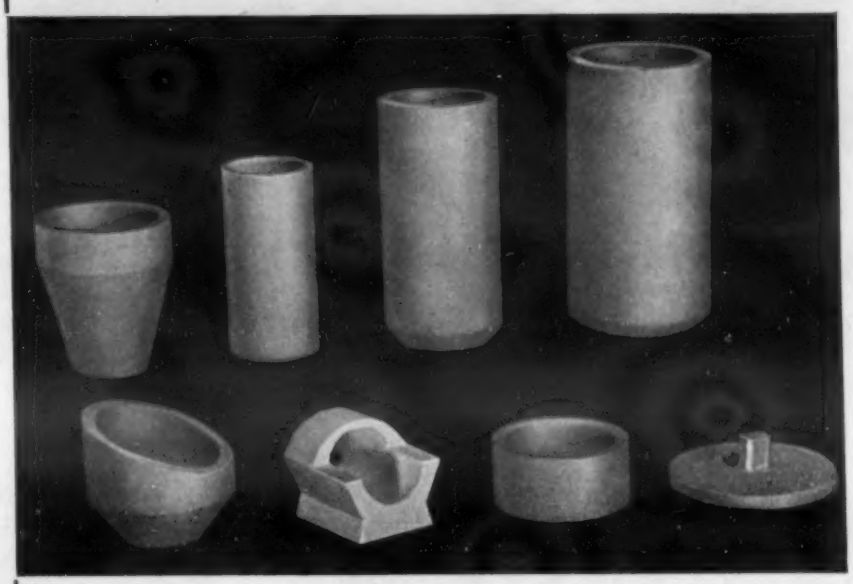
DO YOU NEED A CRUCIBLE



THAT CAN TAKE A BEATING ?

Wesgo crucibles and other refractory shapes will not crack or spall under the most severe conditions. Thus a white hot crucible may be "dunked" in cold water without suffering damage. Various shaped crucibles that may be used at temperatures up to 3300 degrees F., are stocked.
We solicit your inquiries for special sizes and shapes as well as our stock sizes of crucibles and other refractory articles.

WESTERN GOLD AND PLATINUM WORKS
589 Bryant Street — San Francisco, Calif.

By Edwin F. Cone, Editor

Industrial Electric Furnaces

Today electric furnaces are playing a leading role in heat treating thousands of different parts and subassemblies for war devices of all kinds, according to a statement by C. L. Ipsen of the General Electric Co. Production during the first half of 1942 has been 16 times greater than any pre-war half year. This increase is pointed to as foreshadowing an even more extensive application after the war.

Nickel in Armor

The armed services are making good progress in the conservation of materials, says the *Daily Metal Trade*. This is indicated by the fact that wrought armor plate production has increased 250 per cent since February, while the use of nickel rose only 22 per cent.

Effective Company Literature

A decided improvement in the quality and dress of some of the company literature which almost daily comes across an editor's desk is distinctly noticeable. Some of them are strikingly impressive. One of these has recently been published by the Vanadium Corp. of America — "Soldiers of Production" — which in pictorial effect and appeal is outstanding.

Conserving Copper and Brass

A few of the examples, cited in an article in the *Daily Metal Trade,* whereby copper and brass are being conserved are as follows: Steel stampings, zinc die castings or malleable iron as hardware for belts and haversacks; plastics for brass safety razors; steel for aluminum and copper in field ranges; and steel also for 60 per cent of the phosphor bronze and brass snap fasteners.

Steel Castings

Production of steel castings continues to maintain the record volume registered in the first half of this year. Data for July show that the total output (961,431 net tons) to Aug. 1 is nearly 36 per cent in excess of the same 7 mos. in 1941 and about 130 per cent over the total to Aug. 1, 1940. To Aug. 1, this year, miscellaneous castings were made up over 74 per cent of the total at 713,-015 tons. The remainder is classified as railway specialties.

Manufacturers reported for July 1942 an actual monthly capacity of 159,259 tons. July output therefore was about 84 per cent of capacity. The Bureau of Census, Dept. of Commerce, which publishes these data, says that the July data were compiled from the returns of 193 producers who make castings for sale while for the first half the returns came from 187 foundries. Of the companies not reporting in 1941, there now are 14 sending in data. The elimination of 8 foundries is reported, 6 that discontinued and 2 that merged with other companies.

Saving Tin Plate in Cans

Substitution of electrolytic tin plate and of bonderized steel ends for cans, in such cases where this is permissible, will save, it is estimated, 3,500 tons of tin plate per year by 1943. Substitution of electrolytic tin plate bodies and bonderized steel ends wherever practical will save an additional 4,300 tons of tin plate, a total of 7,800 tons a year, according to WPB. Substitution of these materials for both bodies and ends will make an additional estimated saving of 3,300 tons — the total estimated savings by this program to be about 10,000 tons per year by 1943.

More Domestic Chromium

"Chromium output in this country next year will be 250 times greater than in 1940" says a news statement from WPB. Three times the tonnage used in 1939 will be needed. Large low-grade deposits of ore have been developed in Montana, California and Oregon. "The domestic output in 1943 will therefore be as large as prewar imports." The situation is still regarded as critical, however.

Detinning Plants

Contracts for six new detinning plants are reported to have been awarded in October as well as for the addition of shredding and cleaning departments at four of the existing plants. When this detinning capacity is available, it is estimated the capacity will be about 750,000 tons of material treated or more than double that for any one year. There are 7 detinning plants now in operation in the country.

More Corrosion Research

Research in corrosion has for many years been a major consideration. The Electrochemical Society has expanded this important activity by organizing a Corrosion Division. A permanent organization was established at the Society's fall convention in Cleveland early in October.

(Additional "Trends" on page 1028)

Let a Meehanite Foundry
Solve Your Casting Problems

Ansonia, Conn.
Farrel-Birmingham Co., Inc.

Bridgewater, Mass.
The Henry Perkins Co.

Buffalo, N. Y.
Pohlman Foundry Co., Inc.

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Kanawha Manufacturing Co.

Chattanooga, Tenn.
Ross-Meehan Foundries

Chicago, Ill.
Greenlee Foundry Company

Cincinnati, Ohio
Cincinnati Grinders Incorporated

Cincinnati, Ohio
The Cincinnati Milling Machine Co.

Cleveland, Ohio
Fulton Foundry & Machine Co.

Denver, Colo.
The Stearns-Roger Mfg. Co.

Detroit, Mich.
Atlas Foundry Co.

Flint, Mich.
General Foundry & Mfg. Company

Hamilton, Ohio
The Hamilton Foundry & Machine Co.

Irvington, N. J.
Barnett Foundry & Machine Co.

Los Angeles, Calif.
Kinney Iron Works

Milwaukee, Wis.
Koehring Company

Mt. Vernon, O., Grove City, Pa.
Cooper-Bessemer Corporation

New York, N. Y.
The American Brake Shoe & Foundry Co.

Oakland, Calif.
Vulcan Foundry Company

Orillia, Canada
E. Long, Ltd.

Philadelphia & Bethayres, Pa.
H. W. Butterworth & Sons Co.

Philadelphia, Pa.
Florence Pipe Foundry & Machine Co., (R. D. Wood Company, Selling Agents)

Phillipsburg, N. J.
Warren Foundry & Pipe Corp.

Pittsburgh, Pa.
Meehanite Metal Corporation

Pittsburgh, Pa.
Rosedale Foundry & Machine Co.

Rochester, N. Y.
American Laundry Machinery Co.

St. Louis, Mo.
Banner Iron Works

St. Paul, Minn.
Valley Iron Works

London, Eng.
The International Meehanite Metal Co., Ltd.

Waterloo, N. S. W.
Australian Meehanite Metal Co., Ltd.

Johannesburg, South Africa
Meehanite Metal Co. (S.A.) (Pty.) Ltd

These QUICK FACTS about

Meehanite

may help you solve today's design and production problems

WHAT IS MEEHANITE?

MEEHANITE is a special metal for castings which combines the better features of both cast iron and steel. Meehanite castings offer the engineer reliable and favorable design characteristics as described below.

TYPES

There are twenty-one types of Meehanite, each having a different combination of physical properties aimed toward meeting definite service requirements.

PHYSICAL PROPERTIES

Varying with the requirements of the service, Meehanite in its several types (as cast) produces tensile strengths up to 55,000 lb. p.s.i.; compressive strengths up to 200,000 lb. p.s.i.; moduli of rupture in bending from 61,000 to 93,000 lb. p.s.i. These and other properties such as yield point, modulus of elasticity, hardness, torsonial and shear strength, fatigue strength, etc., are known and reliable.

HEAT TREATMENT

For higher strength and hardness, Meehanite is adaptable to heat-treatment and flame hardening. Accurate information is available on these subjects, as well as on the effect of elevated temperatures (50°F. to 1100°F.) on strength, creep, surface metal loss.

MACHINABILITY

Machinability rating tests prove Meehanite more machinable than steel or alloy iron castings. This important advantage of Meehanite is due to two factors, (a) the constitution of the metal frequently permits substantially increased machining speeds, (b) dimensional accuracy and smooth cast surfaces mean less metal need be removed in finishing.

VIBRATION DAMPING

A unique combination of high damping capacity and high strength gives Meehanite castings a prominent position in the construction of precision machinery, and in highly stressed machinery parts where weight, noise and possibility of fatigue failure must be kept to the minimum.

WEAR RESISTANCE

Five types of wear-resisting Meehanite offer different combinations of physical properties to meet external problems encountered in wear-resisting service such as: hardness, impact, fatigue, friction, corrosion, lubrication, etc.

HEAT AND CORROSION RESISTANCE

Where heat and corrosion resistance combined with high strength, toughness, etc., are desired, Meehanite is available in types to resist growth, scaling, warpage, and corrosion.

ENGINEERING DATA

Complete data on engineering properties, metallurgy, heat-treatment and manufacture is included in this 47-page book. Sent free to executives, engineers, designers, production and maintenance men of industry. Price to others, $1.00 per copy.

MEEHANITE RESEARCH INSTITUTE, 311 Ross St., Pittsburgh, Pa.

trends

By Edwin F. Cone, Editor

Electrolytic Tin Plate

A major part of the tin plate production next year will be made by the electrolytic process, according to press reports. Just how large this will be is still dependent on the success of producers in training operators and on the removal of troubles often developing in a more or less new process. Most of the new installations will come into production in the first half of 1943 with one or two starting in the last quarter of this year.

The New 5-Cent Coin

Changes in the composition of our coinage have been inaugurated. Secretary Morgenthau of the Treasury announces that the new 5-cent piece will be composed of 35 Ag, 56 Cu and 9 per cent Mn. Manufacture of these has been started at the Philadelphia Mint. The present 5-cent coin is composed of 25 Ni and 75 per cent Cu. The change will save all the nickel and 25 per cent of the copper, releasing them for military purposes.

The Light Metals

There is a strong trend toward differentiating between the light metals, aluminum and magnesium, and the other non-ferrous metals. One technical society, the American Foundrymen's Association, has recently organized an Aluminum and Magnesium Division. At the head of it is Dr. N. E. Woldman, chief metallurgical engineer of the Eclipse Aviation Div. of the Bendix Corp.

Finished Steel Shipments

A measurement of the tempo of the demand for American finished steel is found in the report of the U. S. Steel Corp.'s shipments to Oct. 1, 1942. September shipments of 1,788,650 net tons were the largest on record for that month. The total for the 9 mos. of 15,761,476 tons not only exceeded any similar period but were larger than the total deliveries for 1940 when they were 14,976,110 tons.

A Welded Blast Furnace

The second blast furnace in the Defense Plant Corp.'s program has been built by the Republic Steel Corp. and put in blast. It was blown in Oct. 12. A feature which aided in its rapid construction is that it is practically a welded job. This is Republic's second furnace built for the D.F.C. and has a capacity of 1,100 tons of pig iron a day. It has been built on the site of an old hand-charged furnace whose capacity was only about one-fourth that of the new stack.

Research in Acid Open-Hearth

The Acid Open-Hearth Research Association was formed in Pittsburgh Sept. 14, the purpose being to conduct practical and technical research on problems governing the production of this grade of steel. The director of this research program is Dr. G. R. Fitterer of the department of metallurgy of the University of Pittsburgh. J. W. Linhart is the research metallurgist. At the time of the formation of the association, 19 companies which produce acid open-hearth steel were members. This is another example of the broadening field of research.

Speeding Furnace Construction

By building the shell and superstructure of a new blast furnace on a site adjacent to the old furnace which it replaced, the Youngstown Sheet and Tube Co. saved 67 days of production time because these structures could thus be moved into place at the proper time. The number of days elapsing from the blowing out of the old furnace to filling the new one is reported to have been 83 days. This is regarded as a radical departure from the conventional method of building a furnace.

Savings from Electrolytic Tin Plate

Electrolytic tin plate can be made with as little tin as 0.1 lb. per base box of 100 lbs., though experiments are said to show that a tin deposit of 0.5 lb. per box is more practical for most purposes. This contrasts with the hot dip process which results in a deposit of 1.5 lb. of tin per base box. Adoption of the electrolytic process will mean a substantial saving of tin.

More Magnetite Iron Ore

Magnetite iron ore has been produced in the Adirondack area intermittently for at least 75 yrs. This is now expanding and by the end of 1943 about $30,000,000 will have been spent on new mine development, plant and equipment to produce about 4,000,000 tons of high-grade magnetite sinter each year.

Training with Movies

In training green men and women to do certain war work, use is being made of moving pictures by some companies. Particularly in the case of aluminum, the Aluminum Co. of America has produced three sound films—on riveting, welding and machining of aluminum. These are available to companies operating in this extensive field and are educational and helpful.

(Additional "Trends" on page 1026)